CASE-BY-CASE MACT PERMIT APPLICATION

Texas Gulf Terminals Inc.
Texas Gulf Terminals Project

Appendix D

Prepared By:

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Environmental solutions delivered uncommonly well

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1. INTRODUCTION

1.1. PROJECT BACKGROUND

Texas Gulf Terminals Inc. (TGTI) is proposing to construct, own, and operate a deepwater port (DWP) as part of the Texas Gulf Terminal Project, in Federal waters of the U.S. Gulf of Mexico located approximately 14 miles off the coast of North Padre Island in Kleberg County, Texas.

The purpose of the proposed project is to provide a safe, efficient and cost effective logistical solution for the export of crude oil from the United States of America (U.S.) to support the continued economic growth of the U.S.

The DWP terminal will include a Single Point Mooring (SPM) buoy system to moor a Very Large Crude Carrier (VLCC). The size of these VLCCs and inland port draft limitations prevent them from using the traditional docks at onshore terminals. Therefore, VLCCs have to be engaged offshore. The proposed SPM buoy system will be located in water with over 90 feet of depth, allowing a VLCC to be fully and directly loaded without the use of lightering (i.e., using smaller ships to transport crude oil from on-shore terminals out to VLCCs located in deeper waters).

The project will serve as a crude oil export facility with a capacity of 60,000 barrels per hour (bph) and 192 million barrels per year. The project will be able to load approximately 96 VLCCs per year. The proposed project is comprised of two major offshore components: the SPM Buoy system and the offshore pipelines. A detailed description of the SPM Buoy system components and the offshore pipeline system is provided in Section 3.

1.2. PURPOSE OF APPLICATION

The proposed SPM buoy system will represent a major source of HAP emissions that is not specifically regulated or exempted from regulation under a standard issued pursuant to section 112(d), section 112(h) or section 112(j) and incorporated in another subpart of part 63. Accordingly, the requirements of 40 CFR 63.40 through 63.44 apply. The regulations contained in 40 CFR 63.40 through 63.44 carry out section 112(g)(2)(B) of the Clean Air Act (CAA) as it relates to a Case-by-Case MACT determination. As such, TGTI has prepared a Case-by-Case MACT determination application in accordance with 40 CFR 63.40 through 63.44 and Section 112(g) of the CAA.

To reach this conclusion, TGTI conducted an extensive review of each of the National Emissions Standards for Hazardous Air Pollutants (NESHAP) regulation to identify any potentially applicable NESHAP regulations that might apply to the proposed SPM buoy system. Only one type of NESHAP regulations was identified that could be potentially applicable to the proposed SPM buoy system: NESHAP Subpart Y – National Emissions Standards for Marine Tank Vessel Loading Operations. The following section details why TGTI concluded NESHAP Subpart Y does not apply to the proposed SPM buoy system.

1.2.1. NESHAP Subpart Y – Marine Tank Vessel Loading Operations Inapplicability

NESHAP Subpart Y applies to affected sources of Marine Tank Vessel Loading Operations. The following definitions from NESHAP Subpart Y (40 CFR 63.561) are important provisions used to determine what qualifies as an affected source regulated under NESHAP Subpart Y.

> ***Affected source*** *means a source with emissions of 10 or 25 tons, a new major source with emissions less than 10 and 25 tons, a new major source offshore loading terminal, a source with throughput of 10 M barrels or 200 M barrels, or the VMT source, that is subject to the emission standards in §63.562.*
>
> ***Source(s)*** *means any location where at least **<u>one dock or loading berth</u>** is bulk loading onto marine tank vessels, except offshore drilling platforms and lightering operations.*
>
> ***Offshore Loading Terminal*** *means a location that has at least **<u>one loading berth</u>** that is 0.81 km (0.5 miles) or more from the shore that is used for mooring a marine tank vessel and loading liquids from shore."*
>
> ***Loading berth*** *means the loading arms, pumps, meters, shutoff valves, relief valves, and other piping and valves necessary to fill marine tank vessels. The loading berth includes those items necessary for an offshore loading terminal.*

The proposed SPM buoy system does not fit the definition of a "loading berth" per the definition set forth in 40 CFR 63.561 since the proposed SPM buoy system will not have loading arms, pumps, meters, shutoff valves, nor relief valves. Additionally, the proposed SPM buoy system does not have a "dock" or any fixed structure resembling a dock structure. Per the Cambridge Dictionary, a dock is defined as "a structure built out over the water in a port along which ships can land to load and unload, or the enclosed area of water between two such structures."

Therefore the proposed SPM buoy system does not fit the definition of an "affected source" because it does not meet the definition of a "source" as stated in 40 CFR 63.561.

The definitions of "offshore loading terminal" and "loading berth" are essentially circular. Therefore, TGTI also reviewed the NESHAP Subpart Y preamble and technological support documents to determine if there were any sources similar to the proposed SPM buoy system that were considered in the rulemaking. Based on this review, TGTI concluded that there were no similar sources to the proposed SPM buoy system (i.e., SPM buoy systems for directly and completely loading a VLCC for crude oil export) considered in the development of the NESHAP Subpart Y regulations. The proposed SPM buoy system will be a first of its kind for the United States. Export of crude oil was banned in the United States from 1975, following the 1973 OPEC oil embargo, until 2015 to all countries except Canada. Therefore, because of this legal restriction, there could not have been similar sources in operation when NESHAP Subpart Y was developed in 1995 nor when it was reconsidered in 2011.

The proposed SPM buoy system also presents unique technical, environmental, and operational concerns compared to the sources that were considered in the establishment of MACT Subpart Y standards. EPA acknowledged in responses to comments on the 1995 NESHAP Subpart Y rule that the subcategory established for "offshore terminals" could be expanded to include additional subcategories based on throughputs, products handled, etc. It did not, however, consider doing so in 1995 because the public comments did not justify additional subcategories. This reinforces TGTI's conclusion that the proposed SPM buoy system is not an affected source under NESHAP Subpart Y.

1.2.2. Case-by-Case MACT Submittal

Since there are no applicable standards in either 40 CFR Part 61 or Part 63 that apply to the proposed SPM buoy system, this Case-by-Case MACT application has been prepared to present a Case-by-Case MACT determination for the proposed SPM buoy system in accordance with Section 112(g) of the Clean Air Act (CAA) and the implementing regulations in 40 CFR Part 63, Subpart B (40 CFR 63.40 – 63.56). Since Texas is the most adjacent seaward state, TCEQ regulations are also potentially applicable. Therefore, this application is also being submitted in accordance with 30 TAC Chapter 116, Subchapter E which implements Section 112(g) and 40 CFR Part 63, Subchapter B.

2. APPLICANT INFORMATION: TCEQ FORMS

CORE DATA FORM

PI-1 FORM

TABLE 1(a)

TCEQ Core Data Form

TCEQ Use Only

For detailed instructions regarding completion of this form, please read the Core Data Form Instructions or call 512-239-5175.

SECTION I: General Information

1. Reason for Submission (If other is checked please describe in space provided.)

☒ New Permit, Registration or Authorization (Core Data Form should be submitted with the program application.)

☐ Renewal (Core Data Form should be submitted with the renewal form) ☐ Other

2. Customer Reference Number (if issued)	Follow this link to search for CN or RN numbers in Central Registry**	3. Regulated Entity Reference Number (if issued)
CN 605490085		RN

SECTION II: Customer Information

4. General Customer Information

5. Effective Date for Customer Information Updates (mm/dd/yyyy)

☐ New Customer ☐ Update to Customer Information ☐ Change in Regulated Entity Ownership

☐ Change in Legal Name (Verifiable with the Texas Secretary of State or Texas Comptroller of Public Accounts)

The Customer Name submitted here may be updated automatically based on what is current and active with the Texas Secretary of State (SOS) or Texas Comptroller of Public Accounts (CPA).

6. Customer Legal Name (If an individual, print last name first: e.g.: Doe, John)

Texas Gulf Terminals Inc.

If new Customer, enter previous Customer below:

7. TX SOS/CPA Filing Number	8. TX State Tax ID (11 digits)	9. Federal Tax ID (9 digits)	10. DUNS Number (if applicable)
0802978324	32066715692		

11. Type of Customer: ☒ Corporation ☐ Individual Partnership: ☐ General ☐ Limited

Government: ☐ City ☐ County ☐ Federal ☐ State ☐ Other ☐ Sole Proprietorship ☐ Other:

12. Number of Employees

☒ 0-20 ☐ 21-100 ☐ 101-250 ☐ 251-500 ☐ 501 and higher

13. Independently Owned and Operated?

☒ Yes ☐ No

14. Customer Role (Proposed or Actual) - as it relates to the Regulated Entity listed on this form. Please check one of the following:

☐ Owner ☐ Operator ☒ Owner & Operator

☐ Occupational Licensee ☐ Responsible Party ☐ Voluntary Cleanup Applicant ☐ Other:

15. Mailing Address:

1401 McKinney

Suite 1500

City	Houston	State	TX	ZIP	77010	ZIP + 4	

16. Country Mailing Information (if outside USA)

17. E-Mail Address (if applicable)

18. Telephone Number	19. Extension or Code	20. Fax Number (if applicable)
(832) 203 - 6400		( ) -

SECTION III: Regulated Entity Information

21. General Regulated Entity Information (If `New Regulated Entity" is selected below this form should be accompanied by a permit application)

☒ New Regulated Entity ☐ Update to Regulated Entity Name ☐ Update to Regulated Entity Information

The Regulated Entity Name submitted may be updated in order to meet TCEQ Agency Data Standards (removal of organizational endings such as Inc, LP, or LLC).

22. Regulated Entity Name (Enter name of the site where the regulated action is taking place.)

Texas Gulf Terminals Project

23. Street Address of the Regulated Entity: (No PO Boxes)							
	City		State		ZIP		ZIP + 4
24. County							

Enter Physical Location Description if no street address is provided.

25. Description to Physical Location:	Site is approximately 14 miles offshore the coast of Texas, Southeast of Corpus Christi.		
26. Nearest City		State	Nearest ZIP Code
N/A		TX	N/A

27. Latitude (N) In Decimal:		27.4785	28. Longitude (W) In Decimal:		97.013453
Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
27	28	42.6	97	00	48.43

29. Primary SIC Code (4 digits)	30. Secondary SIC Code (4 digits)	31. Primary NAICS Code (5 or 6 digits)	32. Secondary NAICS Code (5 or 6 digits)
4612		486910	

33. What is the Primary Business of this entity? (Do not repeat the SIC or NAICS description.)

Offshore Marine Terminal

34. Mailing Address:	1401 McKinney						
	Suite 1500						
	City	Houston	State	TX	ZIP	77010	ZIP + 4
35. E-Mail Address:							

36. Telephone Number	37. Extension or Code	38. Fax Number (if applicable)
(832) 203 - 6400		( ) -

39. TCEQ Programs and ID Numbers Check all Programs and write in the permits/registration numbers that will be affected by the updates submitted on this form. See the Core Data Form instructions for additional guidance.

☐ Dam Safety	☐ Districts	☐ Edwards Aquifer	☐ Emissions Inventory Air	☐ Industrial Hazardous Waste
☐ Municipal Solid Waste	☐ New Source Review Air	☐ OSSF	☐ Petroleum Storage Tank	☐ PWS
☐ Sludge	☐ Storm Water	☐ Title V Air	☐ Tires	☐ Used Oil
☐ Voluntary Cleanup	☐ Waste Water	☐ Wastewater Agriculture	☐ Water Rights	☒ Other: Section 112(g)
				Case-by-Case MACT

SECTION IV: Preparer Information

40. Name: Denise Rogers			41. Title: Compliance Manager
42. Telephone Number	43. Ext./Code	44. Fax Number	45. E-Mail Address
(832) 203 - 6493		( ) -	denise.rogers@texasgulfterminals.com

SECTION V: Authorized Signature

46. By my signature below, I certify, to the best of my knowledge, that the information provided in this form is true and complete, and that I have signature authority to submit this form on behalf of the entity specified in Section II, Field 6 and/or as required for the updates to the ID numbers identified in field 39.

Company:	Texas Gulf Terminals Inc	Job Title:	Compliance Manager
Name(*In Print*):	Denise Rogers	Phone:	(832)203-6493
Signature:	Denise Rogers	Date:	6/27/2018

Texas Commission on Environmental Quality
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Air Preconstruction Permit and Amendment
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Important Note: The agency requires that a Core Data Form be submitted on all incoming applications unless a Regulated Entity and Customer Reference Number have been issued and no core data information has changed. For more information regarding the Core Data Form, call (512) 239-5175 or go to www.tceq.texas.gov/permitting/central_registry/guidance.html.

I. Applicant Information		
A. Company or Other Legal Name: Texas Gulf Terminals Inc.		
Texas Secretary of State Charter/Registration Number (if applicable):		
B. Company Official Contact Information: (☐ Mr. ☐ Mrs. ☒ Ms. ☐ Other:) ______		
Name: Denise Rogers		
Title: Compliance Manager		
Mailing Address: 1401 McKinney, Suite 1500		
City: Houston	State: TX	ZIP Code: 77010
Telephone No.: 832-203-6493	Fax No.: 832-203-6401	
E-mail Address: denise.rogers@texasgulfterminals.com		
All permit correspondence will be sent via electronic copies unless hard copies are specifically requested through regular mail. The company official must initial here if hard copy correspondence is requested. ______		
C. Technical Contact Name Information: (☐ Mr. ☐ Mrs. ☒ Ms. ☐ Other:) ______		
Name: Denise Rogers		
Title: Compliance Manager		
Company Name: Texas Gulf Terminals Inc.		
Mailing Address: 1401 McKinney, Suite 1500		
City: Houston	State: TX	ZIP Code: 77010
Telephone No.: 832-203-6493	Fax No.: 832-203-6401	
E-mail Address: denise.rogers@texasgulfterminals.com		
D. Site Name: Texas Gulf Terminals Project		
E. Area Name/Type of Facility:	☒ Permanent ☐ Portable	
For portable units, please provide the serial number of the equipment being authorized below.		
Serial No:	Serial No:	
F. Principal Company Product or Business: Offshore Marine Terminal		
Principal Standard Industrial Classification Code (SIC): 4612		
Principal North American Industry Classification System (NAICS): 486910		
G. Projected Start of Construction Date: TBD		
Projected Start of Operation Date: TBD		

I. Applicant Information (continued)	
H. Facility and Site Location Information (If no street address, provide clear driving directions to the site in writing.):	
Street Address: Site is approximately 14 miles offshore the coast of Texas, Southeast of Corpus Christi.	
City/Town: N/A	County: N/A / ZIP Code: N/A
Latitude (nearest second): 27˚ 28’ 42.6”	Longitude (nearest second): 97˚ 00’ 48.43”
I. Account Identification Number (leave blank if new site or facility):	
J. Core Data Form	
Is the Core Data Form (Form 10400) attached? If No, provide customer reference number and regulated entity number (complete K and L).	☒ YES ☐ NO
K. Customer Reference Number (CN):	
L. Regulated Entity Number (RN):	
II. General Information	
A. Is confidential information submitted with this application? If Yes, mark each confidential page confidential in large red letters at the bottom of each page.	☐ YES ☒ NO
B. Is this application in response to an investigation, notice of violation, or enforcement action? If Yes, attach a copy of any correspondence from the agency and provide the RN in section I.L. above.	☐ YES ☒ NO
C. Number of New Jobs: N/A	
D. Provide the name of the State Senator and State Representative and district numbers for this facility site:	
State Senator: N/A	District No.: N/A
State Representative: N/A	District No.: N/A
III. Type of Permit Action Requested	
A. Mark the appropriate box indicating what type of action is requested.	
☒ Initial ☐ Amendment ☐ Revision (30 TAC § 116.116(e)	
☐ Change of Location ☐ Relocation	
B. Permit Number (if existing):	
C. Permit Type: Mark the appropriate box indicating what type of permit is requested. *(check all that apply, skip for change of location)*	
☐ Construction ☐ Flexible ☐ Multiple Plant ☐ Nonattainment ☐ Plant-Wide Applicability Limit	
☐ Prevention of Significant Deterioration (PSD) ☒ Hazardous Air Pollutant Major Source	
☐ PSD for greenhouse gases (GHGs) ☐ Other:____________	

III. Type of Permit Action Requested *(continued)*			
D. Is a permit renewal application being submitted in conjunction with this amendment in accordance with 30 TAC § 116.315(c).			☐ YES ☒ NO
E. Is this application for a change of location of previously permitted facilities?			☐ YES ☒ NO
If Yes, complete all parts of III.E.			
Current Location of Facility (If no street address, provide clear driving directions to the site in writing.):			
Street Address:			
City:	County:	ZIP Code:	
Proposed Location of Facility (If no street address, provide clear driving directions to the site in writing.):			
Street Address:			
City:	County:	ZIP Code:	
Will the proposed facility, site, and plot plan meet all current technical requirements of the permit special conditions? If "NO," attach detailed information.			☐ YES ☐ NO
Is the site where the facility is moving considered a major source of criteria pollutants or HAPs?			☐ YES ☐ NO
F. Consolidation into this Permit: List any standard permits, exemptions or permits by rule to be consolidated into this permit including those for planned maintenance, startup, and shutdown.			
List: N/A			
G. Are you permitting planned maintenance, startup, and shutdown emissions?			☐ YES ☒ NO
If Yes, attach information on any changes to emissions under this application as specified in VII and VIII.			
H. Federal Operating Permit Requirements (30 TAC Chapter 122 Applicability)			
Is this facility located at a site required to obtain a federal operating permit?			☒ YES ☐ NO ☐ To be determined
If Yes, list all associated permit number(s), attach pages as needed).			
Associated Permit No (s.):			
Identify the requirements of 30 TAC Chapter 122 that will be triggered if this application is approved.			
☐ FOP Significant Revision	☐ FOP Minor	☐ Application for an FOP Revision	
☐ Operational Flexibility/Off-Permit Notification		☐ Streamlined Revision for GOP	
☒ To be Determined		☐ None	

III. Type of Permit Action Requested *(continued)*	
H. Federal Operating Permit Requirements (30 TAC Chapter 122 Applicability) *(continued)*	
Identify the type(s) of FOP(s) issued and/or FOP application(s) submitted/pending for the site. ***(check all that apply)***	
☐ GOP Issued	☐ GOP application/revision application submitted or under APD review
☐ SOP Issued	☐ SOP application/revision application submitted or under APD review
IV. Public Notice Applicability	
A. Is this a new permit application or a change of location application?	☒ YES ☐ NO
B. Is this application for a concrete batch plant? If Yes, complete all parts of V.D.	☐ YES ☒ NO
C. Is this an application for a major modification of a PSD, nonattainment, FCAA § 112(g) permit, or exceedance of a PAL permit?	☐ YES ☒ NO
D. If this is an application for emissions of GHGs, select one of the following:	
☐ separate public notice (requires a separate application)	☒ consolidated public notice
E. Is this application for a PSD or major modification of a PSD located within 100 kilometers or less of an affected state or Class I Area?	☐ YES ☒ NO
If Yes, list the affected state(s) and/or Class I Area(s).	
List:	
F. Is this a state permit amendment application? If Yes, complete all parts of IV.F.	
Is there any change in character of emissions in this application?	☐ YES ☐ NO
Is there a new air contaminant in this application?	☐ YES ☐ NO
Do the facilities handle, load, unload, dry, manufacture, or process grain, seed, legumes, or vegetables fibers (agricultural facilities)?	☐ YES ☐ NO
List the total annual emission increases associated with the application ***(List all that apply and attach additional sheets as needed):***	
Volatile Organic Compounds (VOC):	
Sulfur Dioxide (SO_2):	
Carbon Monoxide (CO):	
Nitrogen Oxides (NO_x):	
Particulate Matter (PM):	
PM 10 microns or less (PM_{10}):	
PM 2.5 microns or less ($PM_{2.5}$):	
Lead (Pb):	
Hazardous Air Pollutants (HAPs):	
Other speciated air contaminants not listed above:	

V. Public Notice Information *(complete if applicable)*		
A. Responsible Person: (☐ Mr. ☐ Mrs. ☐ Ms. ☐ Other:) ______		
Name:		
Title:		
Company Name:		
Mailing Address:		
City:	State:	ZIP Code:
Telephone No.:	Fax No.:	
E-mail Address:		
B. Technical Contact: (☐ Mr. ☐ Mrs. ☐ Ms. ☐ Other:) ___		
Name:		
Title:		
Mailing Address:		
City:	State:	ZIP Code:
Telephone No.:	Fax No.:	
E-mail Address:		
C. Name of the Public Place:		
Physical Address *(No P.O. Boxes)*:		
City:	County:	ZIP Code:
The public place has granted authorization to place the application for public viewing and copying.		☐ YES ☐ NO
The public place has internet access available for the public.		☐ YES ☐ NO
D. Concrete Batch Plants, PSD, and Nonattainment Permits		
County Judge Information (For Concrete Batch Plants and PSD and/or Nonattainment Permits) for this facility site.		
The Honorable:		
Mailing Address:		
City:	State:	ZIP Code:

V. Public Notice Information *(complete if applicable)*	
D. Concrete Batch Plants, PSD, and Nonattainment Permits *(continued)*	
Is the facility located in a municipality or an extraterritorial jurisdiction of a municipality? ***(For Concrete Batch Plants)***	☐ YES ☐ NO
Presiding Officers Name(s):	
Title:	
Mailing Address:	
City: State: ZIP Code:	
Provide the name, mailing address of the chief executive for the location where the facility is or will be located.	
Chief Executive:	
Mailing Address:	
City: State: ZIP Code:	
Provide the name, mailing address of the Indian Governing Body for the location where the facility is or will be located.	
Indian Governing Body:	
Mailing Address:	
City: State: ZIP Code:	
Identify the Federal Land Manager(s) for the location where the facility is or will be located.	
Federal Land Manager(s):	
E. Bilingual Notice	
Is a bilingual program required by the Texas Education Code in the School District?	☐ YES ☐ NO
Are the children who attend either the elementary school or the middle school closest to your facility eligible to be enrolled in a bilingual program provided by the district?	☐ YES ☐ NO
If Yes, list which languages are required by the bilingual program?	
VI. Small Business Classification *(Required)*	
A. Does this company (including parent companies and subsidiary companies) have fewer than 100 employees or less than $6 million in annual gross receipts?	☐ YES ☒ NO
B. Is the site a major stationary source for federal air quality permitting?	☒ YES ☐ NO
C. Are the site emissions of any regulated air pollutant greater than or equal to 50 tpy?	☒ YES ☐ NO
D. Are the site emissions of all regulated air pollutants combined less than 75 tpy?	☒ YES ☐ NO

VII. Technical Information			
A. The following information must be submitted with your Form PI-1 ***(this is just a checklist to make sure you have included everything)***			
☒ Current Area Map ☒ Plot Plan ☒ Existing Authorizations ☒ Process Flow Diagram ☒ Process Description ☒ Maximum Emissions Data and Calculations ☒ Air Permit Application Tables ☒ Table 1(a) (Form 10153) entitled, Emission Point Summary ☐ Table 2 (Form 10155) entitled, Material Balance ☒ Other equipment, process or control device tables			
B. Are any schools located within 3,000 feet of this facility?			☐ YES ☒ NO
C. Maximum Operating Schedule:			
Hour(s): 24		Day(s): 365	
Week(s): 52		Year(s):	
Seasonal Operation? If Yes, please describe in the space provide below.			☐ YES ☒ NO
Hour(s):		Day(s):	
Week(s):		Year(s):	
D. Have the planned MSS emissions been previously submitted as part of an emissions inventory?			☐ YES ☒ NO
Provide a list of each planned MSS facility or related activity and indicate which years the MSS activities have been included in the emissions inventories. Attach pages as needed.			
MSS Facility(s) or Activity		**Year(s)**	
E. Does this application involve any air contaminants for which a disaster review is required?			☐ YES ☒ NO
If Yes, list which air contaminants require a disaster review.			

VII. Technical Information *(continued)*	
F. Does this application include a pollutant of concern on the Air Pollutant Watch List (APWL)?	☐ YES ☒ NO
G. Are emissions of GHGs associated with this project subject to PSD?	☐ YES ☒ NO
If "yes," provide a list of all associated applications for this project:	
See attachments	
VIII. State Regulatory Requirements **Applicants must demonstrate compliance with all applicable state regulations to obtain a permit or amendment.** *The application must contain detailed attachments addressing applicability or non-applicability; identify state regulations; show how requirements are met; and include compliance demonstrations.*	
A. Will the emissions from the proposed facility protect public health and welfare, and comply with all rules and regulations of the TCEQ?	☒ YES ☐ NO
B. Will emissions of significant air contaminants from the facility be measured?	☐ YES ☒ NO
C. Is the Best Available Control Technology (BACT) demonstration attached?	☒ YES ☐ NO
D. Will the proposed facilities achieve the performance represented in the permit application as demonstrated through recordkeeping, monitoring, stack testing, or other applicable methods?	☒ YES ☐ NO
IX. Federal Regulatory Requirements **Applicants must demonstrate compliance with all applicable federal regulations to obtain a permit or amendment.** *The application must contain detailed attachments addressing applicability or non-applicability; identify federal regulation subparts; show how requirements are met; and include compliance demonstrations.*	
A. Does Title 40 Code of Federal Regulations Part 60, (40 CFR Part 60) New Source Performance Standard (NSPS) apply to a facility in this application?	☐ YES ☒ NO
B. Does 40 CFR Part 61, National Emissions Standard for Hazardous Air Pollutants (NESHAP) apply to a facility in this application?	☐ YES ☒ NO
C. Does 40 CFR Part 63, Maximum Achievable Control Technology (MACT) standard apply to a facility in this application?	☐ YES ☒ NO
D. Do nonattainment permitting requirements apply to this application?	☐ YES ☒ NO
E. Do prevention of significant deterioration permitting requirements apply to this application?	☒ YES ☐ NO
F. Do Hazardous Air Pollutant Major Source [FCAA § 112(g)] requirements apply to this application?	☒ YES ☐ NO
G. Is a Plant-wide Applicability Limit permit being requested?	☐ YES ☒ NO
X. Professional Engineer (P.E.) Seal	
Is the estimated capital cost of the project greater than $2 million dollars?	☒ YES ☐ NO
If Yes, submit the application under the seal of a Texas licensed P.E.	

XI. Permit Fee Information	
Check, Money Order, Transaction Number, ePay Voucher Number: N/A	
Fee Amount: $ N/A	
Paid online? N/A	☐ YES ☐ NO
Company name on check:	
Is a Table 30 (Form 10196) entitled, Estimated Capital Cost and Fee Verification, attached?	☐ YES ☐ NO ☒ N/A
XII. Delinquent Fees and Penalties	
This form will not be processed until all delinquent fees and/or penalties owed to the TCEQ or the Office of the Attorney General on behalf of the TCEQ is paid in accordance with the Delinquent Fee and Penalty Protocol. For more information regarding Delinquent Fees and Penalties, go to the TCEQ Web site at: www.tceq.texas.gov/agency/fees/delin.	
XIII. Signature	
The signature below confirms that I have knowledge of the facts included in this application and that these facts are true and correct to the best of my knowledge and belief. I further state that to the best of my knowledge and belief, the project for which application is made will not in any way violate any provision of the Texas Water Code (TWC), Chapter 7; the Texas Health and Safety Code, Chapter 382, the Texas Clean Air Act (TCAA) the air quality rules of the Texas Commission on Environmental Quality; or any local governmental ordinance or resolution enacted pursuant to the TCAA. I further state that I understand my signature indicates that this application meets all applicable nonattainment, prevention of significant deterioration, or major source of hazardous air pollutant permitting requirements. The signature further signifies awareness that intentionally or knowingly making or causing to be made false material statements or representations in the application is a criminal offense subject to criminal penalties.	
Name: Denise Rogers	
Signature: Denise Rogers *Original Signature Required*	
Date: 6/27/2018	

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Table 1(a) Emission Point Summary

Date:	July 2018	**Permit No.:**	TBD	**Regulated Entity No.:**	
Area Name:	Texas Gulf Terminals Project			**Customer Reference No.:**	CN605490085

Review of applications and issuance of permits will be expedited by supplying all necessary information requested on this Table.

AIR CONTAMINANT DATA					
1. Emission Point			**2. Component or Air Contaminant Name**	**3. Air Contaminant Emission Rate**	
(A) EPN	**(B) FIN**	**(C) NAME**		**(A) POUND**	**(B) TPY**
LOADFUG	LOADFUG	Marine Loading	HAPs	125	200

EPN = Emission Point Number
FIN = Facility Identification Number

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Table 1(a) Emission Point Summary

Date:	July 2018	Permit No.:	TBD	Regulated Entity No.:	
Area Name:	Texas Gulf Terminals Project			Customer Reference No.:	CN605490085

Review of applications and issuance of permits will be expedited by supplying all necessary information requested on this Table.

AIR CONTAMINANT DATA			EMISSION POINT DISCHARGE PARAMETERS										
1. Emission Point			4. UTM Coordinates of Emission Point			Source							
						5. Building	6. Height Above	7. Stack Exit Data			8. Fugitives		
EPN (A)	FIN (B)	Name (C)	Zone	East (Meters)	North (Meters)	Height (Ft.)	Ground (Ft.)	Diameter (Ft.) (A)	Velocity (FPS) (B)	Temperature (°F) (C)	Length (Ft.) (A)	Width (Ft.) (B)	Axis Degrees (C)
LOADFUG	LOADFUG	Marine Loading	14	696278	3041006	120.0	0.0	4.7	50.0	455	360646	283707	0

EPN = Emission Point Number
FIN = Facility Identification Number

3. AFFECTED SOURCE DESCRIPTION AND PROJECT TIMELINE

The following section provides information required for a case-by-case MACT determination as detailed in 40 CFR Part 63. In each case, the requirement is quoted from 40 CFR Part 63 and followed by the relevant information.

3.1.1. Section 63.43(e)(2)(i)

In each instance where a constructed or reconstructed major source would require additional control technology or a change in control technology, the application for a MACT determination shall contain the following information:

The name and address (physical location) of the major source to be constructed or reconstructed;

The unit to be constructed is an SPM buoy system for export of crude oil loaded onto VLCCs. The proposed SPM buoy system will be located within territorial seas of the OCS Mustang Island Area TX3 (Gulf of Mexico), within the Bureau of Ocean Energy Management (BOEM) block number 823. The proposed SPM buoy system is positioned at Latitude N27° 28' 42.60" and Longitude W97° 00' 48.43", approximately 12.7 nautical miles (14.62 statute miles) off the coast of North Padre Island in Kleberg County, Texas. An aerial shot of the location of the proposed SPM buoy system is provided at the end of this section.

3.1.2. Section 63.43(e)(2)(ii)

A brief description of the major source to be constructed or reconstructed and identification of any listed source category or categories in which it is included;

The proposed SPM buoy system will load crude oil/condensate onto VLCCs connected to the SPM buoy system's loading hose. The crude oil/condensate will be supplied from the Onshore Storage Terminal Facility (OSTF) through subsea pipelines to the SPM buoy and onto the vessel being loaded. The overall handling capacity of the proposed SPM buoy system will be 60,000 barrels per hour (bph) and up to 192 million barrels per year (bpy). A process flow diagram is provided at the end of this section.

3.1.3. Section 63.43(e)(2)(iii)

The expected commencement date for the construction or reconstruction of the major source;

Construction of the proposed SPM buoy system is expected to begin in the 1st quarter of 2020, pending the issuance of all necessary permits and licenses.

3.1.4. Section 63.43(e)(2)(iv)

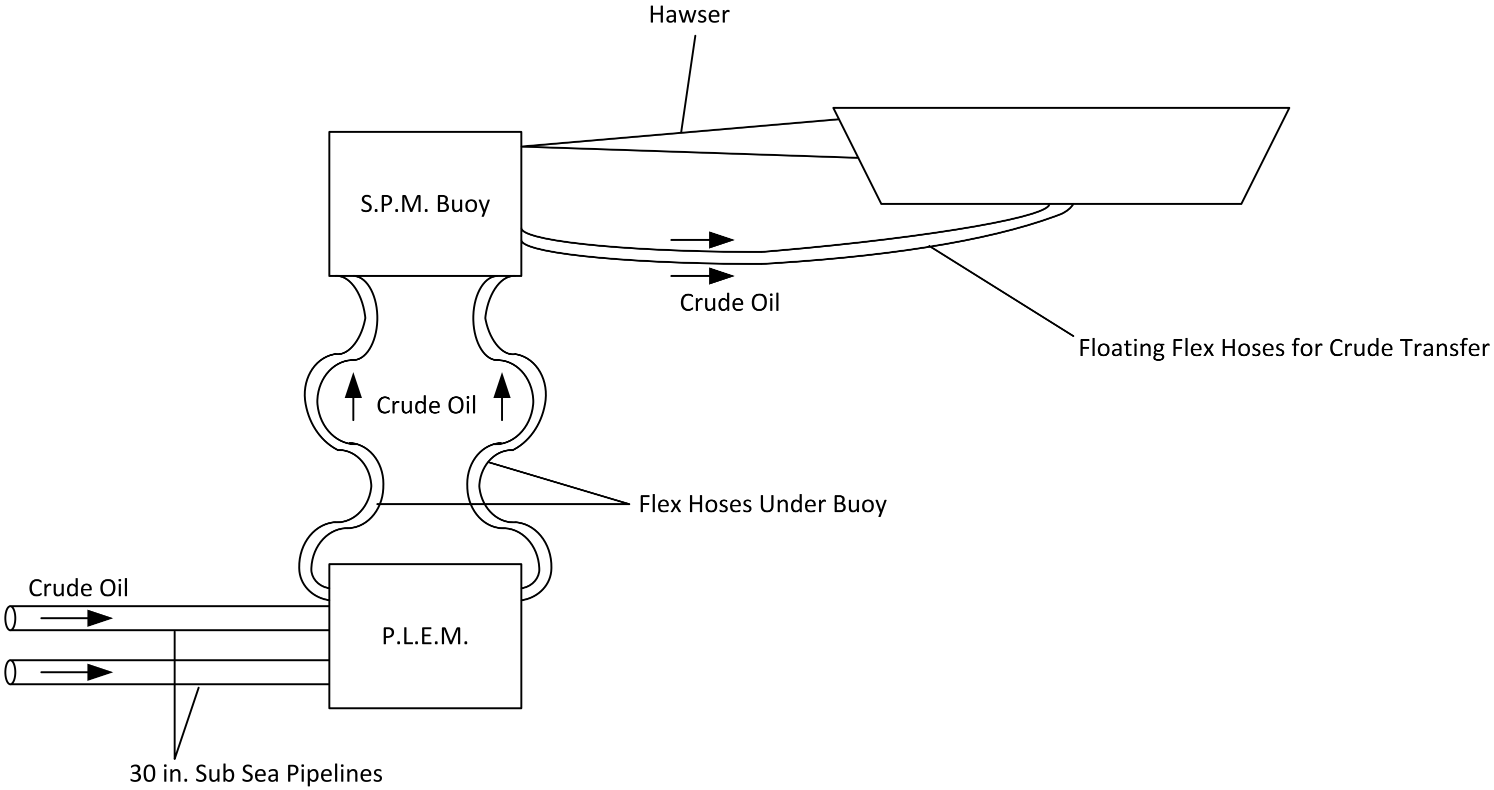
The expected completion date for construction or reconstruction of the major source;

Construction of the SPM buoy system is expected to take approximately 22 weeks. Construction is expected to be completed on the proposed SPM buoy system in the 3rd quarter of 2020.

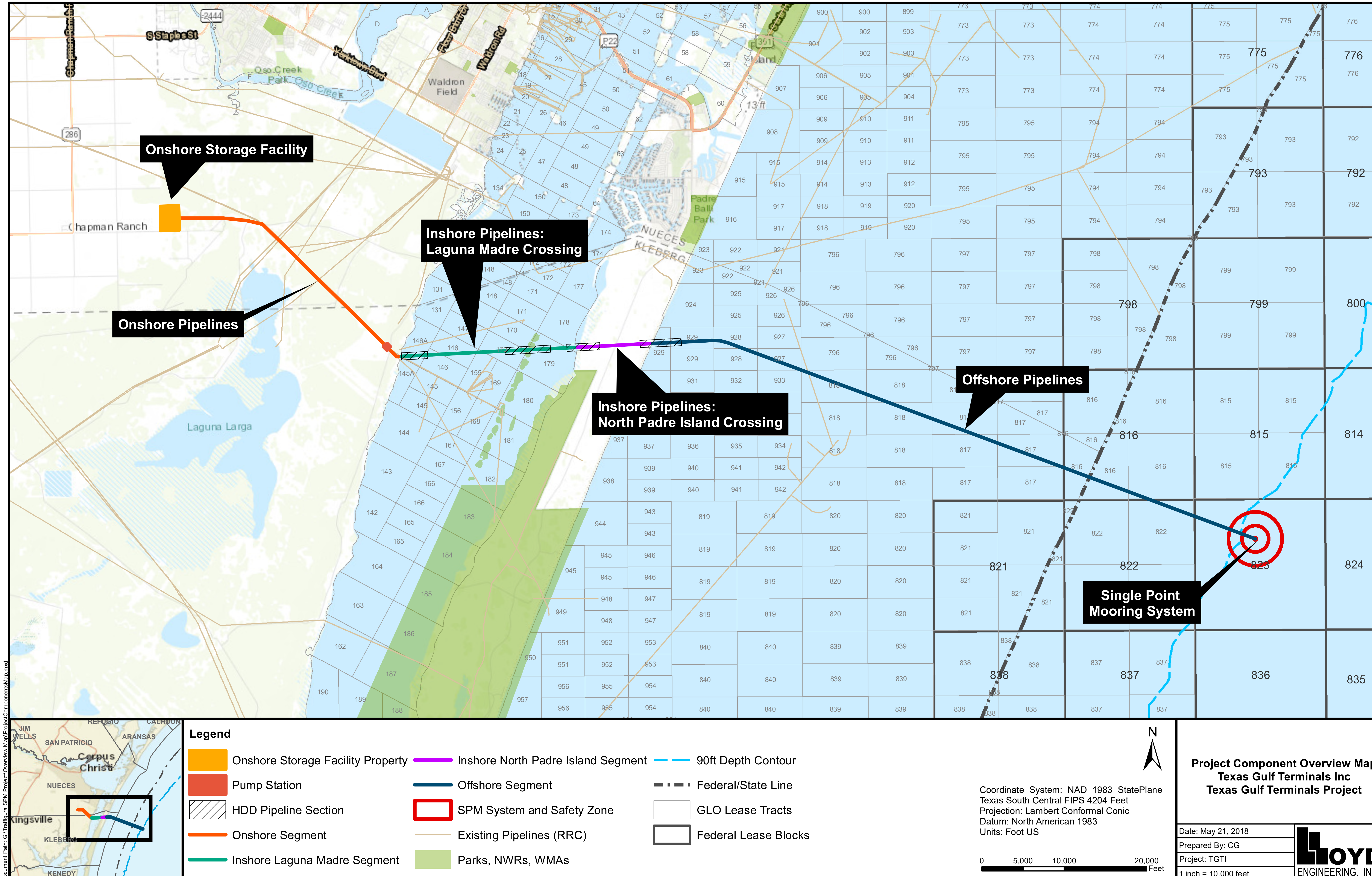
3.1.5. Section 63.43(e)(2)(v)

The anticipated date of start-up for the constructed or reconstructed major source;

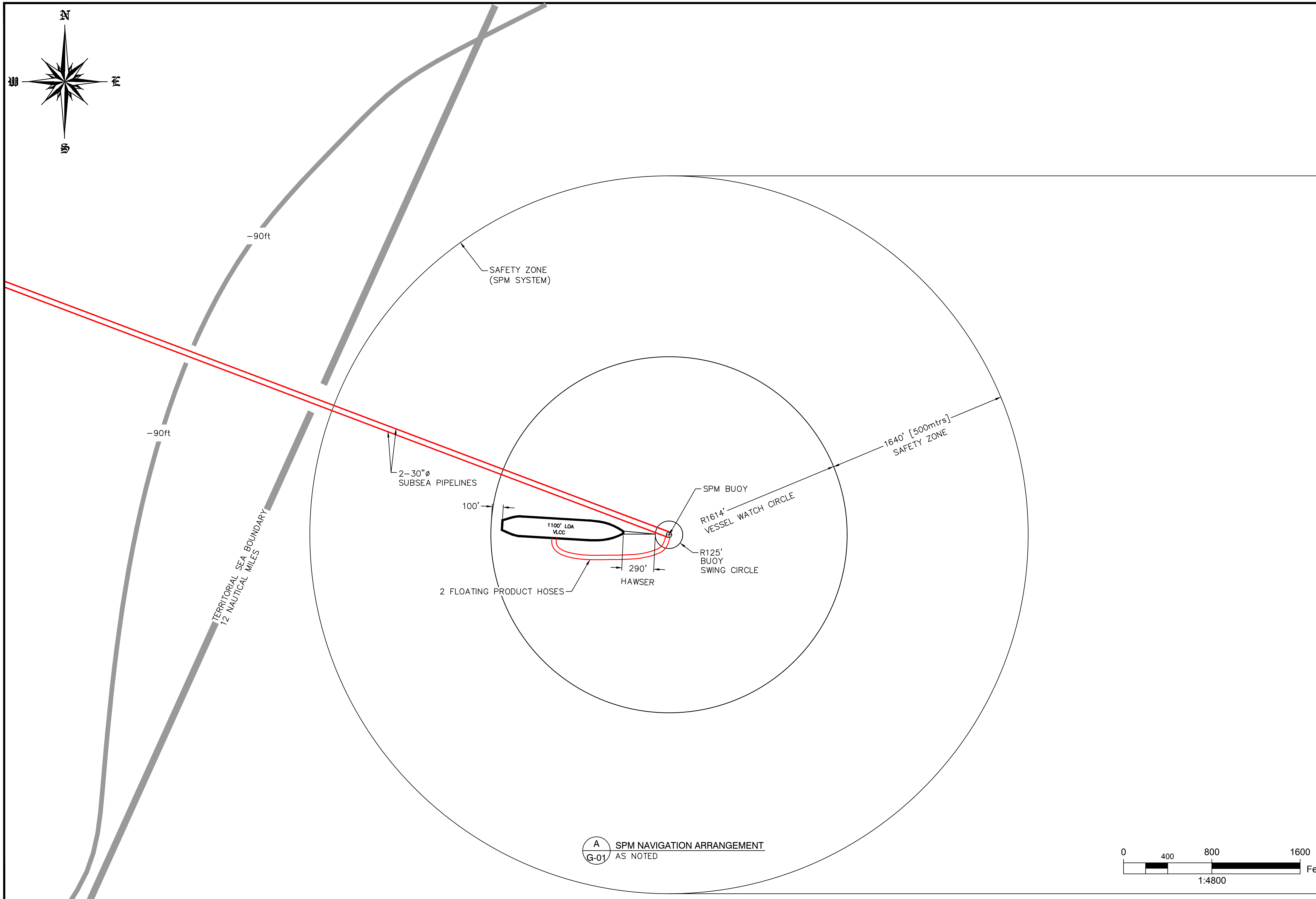
The initial startup of the proposed SPM buoy system is expected to occur shortly after construction is complete in the 3rd quarter of 2020.



Texas Gulf Terminals Inc.
Process Flow Diagram
Trinity Consultants — Project 184403.0005 April 2018



Onshore Storage Facility
Onshore Pipelines
Inshore Pipelines: Laguna Madre Crossing
Inshore Pipelines: North Padre Island Crossing
Offshore Pipelines
Single Point Mooring System
Chapman Ranch
Laguna Larga
Waldron Field
Oso Creek Park
Padre Balli Park
NUECES
KLEBERG
Legend
Onshore Storage Facility Property
Pump Station
HDD Pipeline Section
Onshore Segment
Inshore Laguna Madre Segment
Inshore North Padre Island Segment
Offshore Segment
SPM System and Safety Zone
Existing Pipelines (RRC)
Parks, NWRs, WMAs
90ft Depth Contour
Federal/State Line
GLO Lease Tracts
Federal Lease Blocks
N
Coordinate System: NAD 1983 StatePlane Texas South Central FIPS 4204 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot US
0 5,000 10,000 20,000 Feet
Project Component Overview Map
Texas Gulf Terminals Inc
Texas Gulf Terminals Project
Date: May 21, 2018
Prepared By: CG
Project: TGTI
1 inch = 10,000 feet
LLOYD ENGINEERING, INC.



A
G-01
SPM NAVIGATION ARRANGEMENT
AS NOTED

NO.	DESCRIPTION	DATE	APPR
A	ISSUED FOR REVIEW	MM/DD/YY	-

ISSUED FOR REVIEW

SEAL

TEXAS GULF TERMINALS INC.

CLIENT

TEXAS GULF TERMINALS PROJECT

SPM ARRANGEMENT DETAIL

LLOYD ENGINEERING, INC
HOUSTON TEXAS, USA
LICENSE NO. F-002846

DESIGN BY:	SL
DRAWN BY:	–
DATE:	MARCH 2018
SCALE:	AS NOTED @ 22"X34"
SHEET:	2 OF 2
DRAWING NO:	2
REV. A	

4.1. CRITERIA POLLUTANTS EMISSIONS SUMMARY

4.1.1. Section 63.43(e)(2)(vi)

The HAP emitted by the constructed or reconstructed major source, and the estimated emission rate for each such HAP, to the extent this information is needed by the permitting authority to determine MACT;

HAPs emitted from the proposed SPM buoy system will be those that volatilize from crude oil/condensate as it is loaded onto the VLCC. Detailed emission calculations are provided in Attachment 3.

4.1.2. Section 63.43(e)(2)(vii)

Any federally enforceable emission limitations applicable to the constructed or reconstructed major source;

The PSD/Title V permits issued based on the PSD and Title V permit applications will establish federally enforceable limitations for the proposed SPM system.

4.1.3. Section 63.43(e)(2)(viii)

The maximum and expected utilization of capacity of the constructed or reconstructed major source, and the associated uncontrolled emission rate for that source, to the extent this information is needed by the permitting authority to determine MACT;

As discussed in Section 5 of the NSR application for the proposed SPM buoy system, criteria pollutant emissions from the proposed SPM buoy system will result from loading losses associated with the displacement of air inside the vessel as the vessel is loaded. TGTI estimated the emissions of VOC associated with loading losses of the vessels using TCEQ's Air Permit Technical Guidance for Chemical Sources: Loading Operations (October 2000) and the following equation from US EPA's AP-42, Section 5.2:

$$L = 12.46 \times S \times P \times M/T$$

Where:

L = Loading Loss (lb/10^3 gal of liquid loaded)

S = Saturation factor

P = True vapor pressure of liquid loaded (psia)

M = Molecular weight of vapors (lb/lbmole)

T = Temperature of bulk liquid loaded (R)

A saturation factor of 0.2 is used for submerged loading of ships. A maximum true vapor pressure of 11 psia is used for crude oil/condensate loading.

The maximum loading capacity of the SPM buoy system is 60,000 bph and 192 million bpy. The proposed SPM buoy system is expected to have an expected utilization near 100%. HAP emissions from the proposed SPM buoy system will consist of those HAPs which make up crude oil/condensate. HAP emissions are calculated by assuming the speciation in the vapors lost are the same makeup as the speciation of the crude oil/condensate in the liquid.

4.1.4. Section 63.43(e)(2)(ix)

The controlled emissions for the constructed or reconstructed major source in tons/yr at expected and maximum utilization of capacity, to the extent this information is needed by the permitting authority to determine MACT;

Maximum controlled potential emissions for the proposed SPM system are provided in the table below.

Table 4-1 - Potential HAP Emissions from Proposed SPM Buoy System

Source	HAPs (tpy)
Vessel Loading	200
Fugitives	0.004
Total	**200**

4.2. ALTERNATIVES ANALYSIS

As mentioned in the project background, the purpose of the proposed SPM buoy system will be to fully and directly load VLCCs with crude oil/condensate for export. The proposed SPM buoy system is unique and different from current crude oil/condensate export operations that are currently conducted in the United States. Because of their size (2 MMbbls fully loaded), VLCCs are used for long haul trips to transport cargos long distances across the globe economically. However, their immense size and draft limitations prevents VLCCs from navigating to onshore terminals to be loaded fully. Therefore, VLCCs are currently loaded by lightering, which is the process of using smaller ships to shuttle crude oil/condensate from onshore terminals out to the VLCC. As part of the lightering, crude oil/condensate is loaded onto the VLCC via ship-to-ship (STS) transfer in off-shore waters with a depth that VLCCs can navigate while fully loaded. Emissions from STS transfer during lightering operations are not regulated by CAA regulations and therefore result in uncontrolled emissions of VOC.

Lightering is the current practice for loading VLCCs with crude oil/condensate for export. The STS transfers that occur during the lightering operations generate similar emissions as will occur during when the proposed SPM buoy system conducts its marine tank vessel loading transfer process. However, lightering generates many other emissions during ship movements that do not occur with the SPM buoy system. When comparing wholistic emissions from the entire lightering process to the entire process associated with use of the proposed SPM buoy system, the benefit of the proposed SPM buoy system is clear. Not only does the proposed SPM buoy system reduce the total amount of air emissions, but the proposed SPM buoy system also reduces ship channel traffic and results in a safer and more efficient process to fully load a VLCC with crude oil/condensate for export.

The additional air emissions impacts of lightering compared to the proposed SPM buoy system are generated from the additional combustion emissions required to shuttle the crude oil/condensate on smaller oil tankers from onshore terminals out to the VLCC. With the proposed SPM buoy system, the only tanker involved is the VLCC and it does not have to come any closer to shore than the location of the proposed SPM buoy system, saving on propulsion fuel use. Furthermore, any emissions from the VLCC will be produced further away from the public than those generated by lightering vessels. The table below shows a comparison of the wholistic potential emissions from lightering and the proposed SPM buoy system.

Table 4-2 – Lightering HAP Emissions Comparison

Method	HAPs (tpy)
Lightering[1]	248
SPM Buoy System[2]	201
Savings from Proposed SPM Design	**47**

1. Accounts for full and partial lightering of VLCC based on a representation of historical lightering operations. HAP emissions represent the emissions from STS loading and any *additional* emissions generated in the lightering process (i.e., Loading of the lightering vessel onshore, propulsion of the lightering vessel, etc.).
2. Represents HAP emissions from SPM buoy system operations only (including product loading, propulsion, and various support vessel emissions).
3. Detailed emission calculations are provided under separate cover in the *Air Quality Information for Environmental Impact Statement, Appendix A*.

5. CASE-BY-CASE MACT ANALYSIS

This section discusses the case-by-case MACT determination for the proposed SPM system. TGTI developed a case-by-case MACT under section 112(g) of the CAA and 40 CFR 63, as referenced in 30 TAC Chapter 116, Subchapter E. This case-by-case application was developed because the SPM buoy system will be a major source of HAP emissions that is not regulated by an existing MACT standard. The rationale for and support of the case-by-case MACT are presented in the following section.

5.1. DEFINITION OF MACT

MACT for new sources is defined in 40 CFR §63.41 follows:

> *"Maximum achievable control technology (MACT) emission limitation for new sources" means the emission limitation which is not less stringent than the emission limitation achieved in practice by the best controlled similar source, and which reflects the maximum degree of reduction in emissions that the permitting authority, taking into consideration the cost of achieving such emission reduction, and any non-air quality health and environmental impacts and energy requirements, determines is achievable by the constructed or reconstructed major source.*

This MACT definition applies in two related, but distinct, regulatory contexts for controlling HAP emissions. The first context in which the MACT definition applies is in the development of MACT standards by EPA for specific source categories pursuant to section 112(d) of the CAA. EPA is required to adopt such MACT standards for every listed major source category of HAP emissions through notice and comment rulemaking. The second context in which the MACT definition applies is in regard to the establishment of case-by-case MACT standards for a proposed new (or reconstructed) major source of HAP emissions pursuant to section 112(g) of the CAA. Permitting authorities are required to adopt such case-by-case standards in those instances when EPA has not established a MACT standard under Section 112(d) that applies to the proposed new (or reconstructed) source. This latter case-by-case permitting review is the regulatory context that potentially applies to the proposed SPM system.

5.2. CASE-BY-CASE MACT IMPLEMENTION REGULATIONS

40 CFR §63.43(d) provides the regulatory basis for preparing a Case-by-Case MACT Assessment.

> *(d) Principles of MACT determinations. The following general principles shall be used to make a case-by-case MACT determination concerning construction or reconstruction of a major source under this Rule:*
>
> *(1) The MACT emission limitation or MACT requirements recommended by the applicant and approved by the Division shall not be less stringent than the emission control that is achieved in practice by the best controlled similar source, as determined by the Division.*
>
> *(2) Based upon available information, the MACT emission limitation and control technology (including any requirements under Subparagraph (3) of this Paragraph) recommended by the applicant and approved by the Division shall achieve the maximum degree of reduction in emissions of HAP that can be achieved by utilizing those control technologies that can be identified from the available information, taking into consideration the costs of achieving such emission reduction and any non-air quality health and environmental impacts and energy requirements associated with the emission reduction.*

(3) The owner or operator may recommend a specific design, equipment, work practice, or operational standard, or a combination thereof, and the Director may approve such a standard if the Division specifically determines that it is not feasible to prescribe or enforce an emission limitation under the criteria set forth in Section 112(h)(2) of the federal Clean Air Act.

(4) If the EPA has either proposed a relevant emission standard pursuant to Section 112(d) or 112(h) of the federal Clean Air Act or adopted a presumptive MACT determination for the source category that includes the constructed or reconstructed major source, then the MACT requirements applied to the constructed or reconstructed major source shall have considered those MACT emission limitations and requirements of the proposed standard or presumptive MACT determination.

5.3. SETTING THE MACT LIMIT

40 CFR 63.55 states the requirement for MACT determinations for affected sources subject to case-by-case determination of equivalent emission limitations. 40 CFR 63.55(a)(3) applies to the proposed SPM buoy system and reads as follows:

Each emission limitation for a new affected source must reflect the maximum degree of reduction in emissions of hazardous air pollutants (including a prohibition on such emissions, where achievable) that the permitting authority, taking into consideration the cost of achieving such emission reduction and any non-air quality health and environmental impacts and energy requirements, determines is achievable. This limitation must not be less stringent than the emission limitation achieved in practice by the best controlled similar source which must be established by the permitting authority according to the requirements of section 112(d)(3). This limitation must be based upon available information.

Therefore, setting the MACT limit for the proposed SPM buoy system is a two-part exercise. First, the MACT floor for a new source, which is "the emission control achieved in practice by the best controlled similar source" must be established to determine the minimum acceptable level of emissions control. After conducting an exhaustive search of available information, TGTI has determined the applicable MACT floor for the proposed SPM buoy is submerged fill into a ship. Additionally, TGTI identified ship that are loaded should have developed and implemented a VOC Management Plan using submerged fill in accordance with the requirements of Marine Environment Protection Committee Resolution 185(59) (MEPC.185(59)) as the applicable MACT floor for the proposed SPM buoy system. Details of this search are provided in Section 5.3.1. below.

The second step of setting the Case-by-Case MACT standard is referred to as the "beyond-the-floor" (BTF) analysis. The BTF analysis entails an evaluation of whether it is appropriate to set a MACT standard that is more stringent than the applicable floor level of control determined under the first step. A MACT standard stricter than the applicable MACT floor can be appropriate if justified by an evaluation of available methods and technologies for further limiting emissions. TGTI has evaluated beyond-the-floor emissions control technologies and has determined that a BTF MACT limit is not appropriate for the proposed SPM buoy system and that submerged fill represents the maximum degree of reduction in emissions of HAPs that is achievable.

Each of these requirements is briefly discussed below and, where appropriate, the discussion also explains how these requirements apply to the Case-by-Case MACT determination for the proposed SPM buoy system.

5.3.1. Identifying the Best Controlled Similar Source

The first step in determining the MACT floor is to identify the best controlled similar source, as compared to the design, operational, and performance characteristics of the proposed SPM buoy system. TGTI conducted exhaustive research to identify all potentially similar sources to the proposed SPM buoy. The results of this search are identified in the following sections.

5.3.1.1. MACT Subpart Y Sources

EPA established NESHAP Subpart Y for Marine Vessel Loading Operations in 1995. While NESHAP Subpart Y does not apply to the proposed SPM buoy system, it is the most similar MACT subpart and can offer some insights into the MACT applicability threshold determination for the proposed SPM buoy system.

There is broad authority to "distinguish among classes, types, and sizes of sources" in identifying and evaluating the performance of similar sources for the MACT floor analysis.[1] This step of the analysis – referred to as subcategorization – is an important step in determining the MACT floor, as is discussed in further detail below. Second, Section 112(d)(3) of CAA requires that the MACT floor levels be based on HAP control levels that are "achieved in practice" by the selected best controlled similar source. Courts repeatedly have interpreted this statutory language to require that MACT floors be set at a level that reflects what the best performing source can "achieve under the worst foreseeable conditions."[2]

EPA has subcategorized sources within a general source category in many past MACT rulemakings. In particular, EPA subcategorized sources in their NESHAP Subpart Y rulemakings in 1995 and 2011. In this rulemaking, EPA established the following subcategories for marine vessel loading operations:

- New and existing terminals having throughput of ≥ 1.6 billion liters per year (10 million barrels per year) of gasoline of ≥ 32 billion liters per year (200 million barrels per year) of crude oil;
- Existing major source terminals having emissions of hazardous air pollutants (HAP) of 10/25 tons per year or more from loading of marine tank vessels;
- Existing major source terminals collocated at petroleum refineries having HAP emissions of 10/25 tons per year or more from loading of marine tank vessels; new major source terminals regardless of HAP emissions from marine tank vessel loading (both existing and new sources are regulated under the Gasoline Refineries NESHAP);
- Existing major source terminals regardless of HAP emissions from marine tank vessel loading,
- Existing major source terminals located more than 0.8 kilometers (0.5 miles) offshore;
- New major source terminals located more than 0.8 kilometers (0.5 miles) offshore; and
- Alyeska Pipeline Services Company's Valdez Marine Terminal.

In the case of the proposed SPM buoy system, the subcategories of most interest are those regulating the offshore terminals. In the 1995 development of NESHAP Subpart Y, EPA established no control as the MACT floor for existing offshore terminals and 95% control of HAP emissions for new offshore terminals. These subcategories were again confirmed in 2011 when EPA updated NESHAP Subpart Y regulations adding submerged fill as the new MACT floor for existing offshore terminals and keeping the 95% control requirement for new offshore terminals.

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[1] Section 112(d)(1) of the CAA. This statutory basis for subcategorization was clearly articulated in the Judge Williams' concurring opinion in *Sierra Club v. EPA*, 479 F.3d 875, 884-85 (D.C. Cir. 2007) (hereafter referred to as *"Sierra Club III"*).

[2] *Sierra Club v. EPA*, 167 F.3d 658 (D.C. Cir. 1999) (herein after referred to as "*Sierra Club I*").

In the 1995 rulemaking, EPA estimated that less than 20 offshore terminals with subsea lines were in operation and that none of these facilities controlled emissions from marine tank vessel loading. The EPA received comments that two offshore terminals [just beyond the half mile mark] that do not have subsea lines did control emissions of marine tank vessel loading operations but received no additional information on how or to what degree the emissions were controlled. EPA established a subcategory for offshore terminals based on this very limited information but neglected to consider further additional subcategories for these offshore terminals based on other inherent properties such as types of commodities loaded, the size of the terminal, or the type of operation with which the terminal is associated. As such, the EPA established a MACT floor of 95% control of HAP emissions for new offshore terminals without taking into consideration the additional subcategories of offshore terminals that could be justified. EPA itself admitted that offshore terminals should be broken down into additional subcategories in their summary of public comments and responses on the 1995 NESHAP Subpart Y development.[3]

The proposed SPM system will be unlike any of the sources that were in existence when NESHAP Subpart Y was developed in 1995 and reconsidered in 2011. It will engage in activities that could not be performed during those periods because export of crude oil was banned from 1975 until 2015 as part of the 1975 Energy Policy and Conservation Act. The sole purpose of the proposed SPM buoy system is to fully and completely load VLCC vessels for the export of crude oil/condensate to countries other than the U.S. Therefore, the proposed SPM system will be the only system of its kind in the United States and therefore could not have been considered when the subcategory determinations were conducted in the 1995 and 2011 rulemakings. As explained above, NESHAP Subpart Y is not applicable to the proposed SPM buoy system, and its nature and operational processes make it inherently different than all of the sources that were considered and subcategorized as part of the NESHAP Subpart Y rulemaking. The uniqueness of this source as the only stand-alone SPM DWP capable of directly and fully loading a VLCC for crude oil/condensate export from the United States, demands it be evaluated on a case-by-case basis to determine the level of emission controls that are appropriate for MACT.

5.3.1.2. Santa Barbra Ellwood Marine Terminal

TGTI is aware that the Ellwood Marine Terminal (EMT) in Santa Barbara, California used to operate an SPM buoy system ~0.49 miles off the coast of California for the loading of crude oil and condensate that was produced from the Platform Holly. The EMT was permitted to load barge vessels for the transportation of crude oil from the EMT to refineries throughout California. The EMT has since constructed the infrastructure necessary to transport the crude oil produced by Platform Holly via pipeline and no longer utilizes that SPM buoy system.

When the EMT was in operation, emissions from the loading of the marine barges were controlled by only utilizing two limited-capacity barges Jovalan and Olympic Spirit, which were both equipped with VOC capture and refrigeration control systems. Barge Jovalan (a single hulled barge) was put out of service and replaced by the barge Olympic Spirit (a double hulled barge) in 2010. Neither barge has self-propulsion capabilities and are therefore transported by tug boat to and from each destination. Barge Jovalan had a capacity of 56,000 bbl and Barge Olympic Spirit had a capacity of 80,360. Both barges were loaded at a maximum loading rate of 4,200 bbl/hr from the EMT.

The EMT is not a similar source to the proposed SPM buoy system. The most obvious difference is the major difference in size of the two systems. From 1998 through 2009 the maximum annual throughput of the EMT was

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[3] *Federal Standards for Marine Tank Vessel Loading Operations and National Emission Standards for Hazardous Air Pollutants for Marine Tank Vessel Loading Operations. Technical Support Document for Final Standards: Summary of Public Comments and Responses*. EPA-453/R-95-014. July 1995. Pg. 2-69.

just under 1.4 MMbbl of crude oil loaded onto barges (with a maximum hourly loading rate of 4,200 bbl/hr). The proposed SPM buoy system will have a capacity that is orders of magnitude larger than this with a potential annual throughput of 192 MMbbl/yr and a maximum hourly loading rate of 60,000 bbl/hr. The proposed SPM buoy system will also be located much further off the coast than the EMT, around 14 miles offshore versus 0.49 miles, and will load VLCCs which have a 2 MMbbl capacity.

Additionally, there are no VLCCs in operation that have onboard VOC capture and control technology like the Barges Jovalan and Olympic Spirit used. Even if there were a single VLCC that had onboard VOC capture and control technology, like the two barges used at the EMT for transporting crude, that could be exclusively loaded at the proposed SPM buoy system, the logistics of exporting crude throughout the world would make this an infeasible option. The EMT's two different barges were only used to transport relatively small amounts of crude short distances to refineries in northern or southern California. That practice was totally different from the world-wide deliveries of millions of barrels the VLCC vessels will make after being loaded for those proposes at the SPM buoy system. For these reasons, the EMT is not a similar source to the proposed SPM buoy system, and the EMT's use of small, dedicated barges to control emissions is not considered in the development of the MACT floor for the proposed SPM buoy system.

5.3.1.3. North Sea Shuttle Vessels

Through TGTI's research, they also became aware of plans to construct tanker shuttles in the North Sea that had onboard VOC capture and control. Wartsila and Teekay Offshore Partners have developed and started construction of 4 Suezmax-sized (850,000 bbl capacity) shuttle vessels based on the Shuttle Spirit design.[4] The Shuttle Spirit design is a new shuttle tanker design that allows the tanker to operate using both liquefied natural gas (LNG) as the primary fuel along with VOC that is captured from the oil cargo tanks.[5] The VOC recovery plant uses compression and cooling phases to liquefy the heavier hydrocarbon to be stored in a tank on the deck of the ship.

These sources are not similar to or applicable to the proposed SPM buoy system because of their size differences. The proposed SPM buoy system will only be able to load VLCC vessels with a capacity of 2 MMbbl. The Suezmax-sized vessels being built will only have a capacity of 850,000 bbl and could not load at the proposed SPM buoy system because the cranes aboard Suezmax-sized vessels are not large enough to connect to the proposed SPM buoy system properly. The purpose of the proposed SPM buoy system is to enable full and complete loading of a VLCC vessel for crude oil/condensate export from the United States. Full and complete loading of a VLCC is not possible at onshore terminals since VLCCs exceed the size restrictions on vessels that can navigate to onshore terminals. Therefore, because the proposed SPM buoy system is not designed to load Suezmax-sized vessels, a future-built Suezmax-sized vessel with a VOC recovery plant is not a similar source to the proposed SPM buoy system.

5.3.2. Achieved in Practice

Once the best controlled technology in use by a similar source is identified, the next step is to establish what emissions limitation can be achieved in practice with that control technology. Since submerged loading is not a control technology but rather a standard operating practice, there are no accompanying emissions limitations associated with the use of submerged loading. As provided for in 40 CFR § 63.43(d)(3), a specific design, equipment, work practice, or operational standard, or combination thereof, can be approved in lieu of an

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[4] https://www.teekay.com/blog/2017/11/28/teekay-offshore-partners-places-order-for-two-additional-shuttle-tankers/

[5] https://www.wartsila.com/twentyfour7/in-detail/the-new-shuttle-tanker

emission limitation if it is not feasible to prescribe or enforce an emission limitation under the criteria set forth in Section 112(h)(2) of the Clean Air Act.

Submerged loading in the case of the proposed SPM buoy system is a loading procedure by which the discharge of crude oil/condensate into the VLCC tanks is located at or below the surface of the crude oil/condensate in the vessel. By discharging the crude oil/condensate into the hold at a point below the surface of the liquid, VOC emissions are mitigated compared to splash loading because the surface of the cargo is not disturbed in submerged loading. Compared to splash loading, this minimizes the generation of VOC emissions because it reduces the surface area liquid/vapor interface and thus minimizes the volatilization of hydrocarbons from the liquid.

In addition to submerged loading as a method of VOC control, Regulation 15.6 of the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI requires that all tankers carrying crude oil have an approved and effectively implemented ship specific VOC Management Plan covering at least the points given in the regulation. Guidelines for the development of VOC Management Plans is given in MEPC.185(59) and additional information on systems and operations of VOC Management Plans is given in MEPC.1/Circ.680. For reference, MEPC.185(59) and MEPC.1/Circ.680 have been provided as Attachments 1 and 2, respectively.

The VOC Management Plan is a ship-specific management plan designed to ensure that the operation of a tanker, to which Regulation 15 of MARPOL Annex VI applies, prevents or minimizes VOC emissions to the extent possible. To comply with the plan, the loading and carriage of cargoes which generate VOC emissions should be evaluated and procedures written to ensure that the operations of a ship follow best management practices for preventing and minimizing VOC emissions to the extent possible. With respect to the loading operations at the proposed SPM buoy system, Rule 1.4. of the VOC Management Plan Guideline (MEPC.185(59)) states that while maintaining the safety of the ship, the VOC Management Plan should encourage and set forth the following best management practices as appropriate:

1. The loading procedures should take into account potential gas releases due to low pressure and, where possible, the routing of oil from crude oil manifolds into the tanks should be done so as to avoid or minimize excessive throttling and high flow velocity in pipes;
2. The ship should define a target operating pressure for the cargo tanks. This pressure should be as high as safely possible and the ship should aim to maintain tanks at this level during the loading and carriage of relevant cargo;
3. When venting to reduce tank pressure is required, the decrease in the pressure in the tanks should be as small as possible to maintain the tank pressure as high as possible;
4. The amount of inert gas added should be minimized. Increasing tank pressure by adding inert gas does not prevent VOC release but it may increase venting and therefore increase VOC emissions.

Technical information for the development of VOC Management Plans for tankers carrying crude oil are provided in MEPC.1/Circ.680 (Attachment 2).

Since VOC Management Plans are ship-specific plans, the emission rate of HAPs will vary depending on the specific ship being loaded. Therefore it is not practical to set an emissions limitation for the proposed SPM buoy system. Instead, the following conditions are appropriate as the MACT floor limitation for the proposed SPM buoy system:

> *Submerged loading onto vessels which have onboard and implement a VOC management plan that complies with the requirements of MEPC.185(59).*

5.3.3. Beyond the MACT Floor

Having identified the MACT floor, the next step is to determine if BTF control measures are justified. To date, no SPM buoy systems similar to the proposed SPM buoy system control HAP emissions further than via submerged loading. Not only is this true throughout the waters off the United States, but it is also true for all SPM buoy systems throughout the world. Nonetheless, TGTI has evaluated controlling the loading emissions with a vapor combustion unit (VCU) or a vapor recover unit (VRU) but has eliminated both control technologies from consideration because of the technical and operational infeasibility.

While both VCU and VRU technology have been well established at on shore terminals, the challenges facing implementation of these technologies at a source similar to the proposed SPM buoy system are significantly greater than compared to onshore facilities. In fact, there may be technical challenges that are not yet defined as the technologies identified have never been applied to a source like the proposed SPM buoy system.

5.3.3.1. Vapor Combustion Unit

A VCU captures vapors emitted during loading operations and routes them to a combustion device for control. While this control method reduces the emissions of VOC, it creates collateral emissions increases of pollutants from combustion. Given the location of the proposed SPM buoy system, there is not a suitable location for the VCU equipment. A VCU would require a separate platform or the means for captured vapors to be routed back to an onshore VCU.

Nonetheless, TGTI identified a VCU as a potential control technology because of its demonstrated ability to control emissions from land-based terminals. Though VCUs are demonstrated for land-based terminals, they have not been demonstrated as a control technology on sources similar to the proposed SPM buoy system. Application of VCU technology to the proposed SPM buoy system faces several inherent design challenges when compared to their application at land-based facilities, as identified below.

- Space Limitations
  - The proposed SPM buoy system is a single buoy floating roughly 14 miles offshore. The proposed SPM buoy system is not physically capable of housing equipment necessary for operation of a VCU. Modifications to the SPM buoy system to accommodate a VCU at the source is not a technically feasible option. Such modification would require the design and construction of a novel platform and vapor collection system that has not been demonstrated before. Such a platform would have to be located outside of the designated “swing circle” around the SPM buoy. The swing circle is the area around the SPM buoy in which the ship being loading is allowed to weathervane, or swing, around the SPM buoy during loading. This process is essential to the safety and design of the SPM buoy system as it allows the ship to optimally position itself around the SPM buoy to minimize the forces on the SPM buoy system. To allow for this movement pattern, a platform housing a VCU would have to be located safely outside of this circle, which is typically on the order of 1,500 to 2,000 ft in all directions. The vapor collection system would consist of a vapor collection line back to the SPM buoy, down to a subsea pipeline, then out to the VCU platform via this subsea pipeline. A vapor collection system of this manner has not been demonstrated in practice.
- Safety and Reliability Considerations Due to Variability in Operating Conditions

- As described above, the vapor collection system that would be required for a VCU at the SPM buoy would be a new and unique system that is not currently in place at an SPM buoy system. The distance that the vapor collection line will have to travel underwater presents a reliability concern for the system. The long distance traversed by the vapor collection lines underwater increases the chances of condensed vapors in the vapor collection lines which would create both operational reliability and safety concerns. The other main concern is the constantly variable ocean conditions. Since the VCU equipment would have to be located on a floating platform, the natural motion of ocean waves will disturb the operation of the VCU and lead to unavoidable safety and reliability concerns.

Given the technical issues cited above, VCU control technology is not an “applicable” technology to the proposed SPM buoy system since it cannot reasonably be installed and operated on the source type under consideration. Therefore, VCU technology is eliminated from consideration as a technically infeasible control option for BTF MACT control.

5.3.3.2. Vapor Recovery Unit

A VRU captures vapors emitted during loading operations then routes them to VRU equipment to be absorbed and reintroduced into the process. The captured vapors are converted back into a liquid by using refrigeration, absorption, adsorption, and/or compression. Given the location of the proposed SPM buoy system, there is not a suitable location for the VRU equipment. A VRU would require a separate platform or the means for captured vapors to be routed back to an onshore VRU.

TGTI identified a VRU as a potential control technology because of its demonstrated ability to control emissions from land-based terminals. Though VRUs are demonstrated for land-based terminals, they have not been demonstrated as a control technology on sources similar to the SPM buoy system. Application of VRU technology to the proposed SPM buoy system faces several design challenges when compared to their application at land-based facilities, as identified below.

- Space Limitations
  - The proposed SPM buoy system is a single buoy floating roughly 14 miles offshore. The proposed SPM buoy system is not physically capable of housing equipment necessary for operation of a VRU. Modifications to the SPM buoy system to accommodate a VRU at the source is not a technically feasible option. Such modification would require the design and construction of a novel platform and vapor collection system that has not been demonstrated before. Such a platform would have to be located outside of the designated “swing circle” around the SPM buoy. The swing circle is the area around the SPM buoy in which the ship being loading is allowed to weathervane, or swing, around the SPM buoy during loading. This process is essential to the safety and design of the SPM buoy system as it allows the ship to optimally position itself around the SPM buoy to minimize the forces on the SPM buoy system. To allow for this movement pattern, a platform housing a VRU would have to be located safely outside of this circle, which is typically on the order of 1,500 to 2,000 ft in all directions. The vapor collection system would consist of a vapor collection line back to the SPM buoy, down to a subsea pipeline, then out to the VRU platform via this subsea pipeline. A vapor collection system of this manner has not been demonstrated in practice.

- Safety and Reliability Considerations Due to Variability in Operating Conditions
  - As described above, the vapor collection system that would be required for a VRU at the SPM buoy would be a new and unique system that is not currently in place at an SPM buoy system. The distance that the vapor collection line will have to travel underwater presents a reliability concern for the system. The long distance traversed by the vapor collection lines underwater increases the chances of condensed vapors in the vapor collection lines which would create both operational reliability and safety concerns. The other main concern is the constantly variable ocean conditions. Since the VRU equipment would have to be located on a floating platform, the natural motion of ocean waves will disturb the operation of the VRU and lead to unavoidable safety and reliability concerns. Traditional VRU control technology uses a tall absorber tower that, because of the height, will experience large oscillations at the tip, even from relatively small movement at the base from waves.

Given the technical issues cited above, VRU control technology is not an “applicable” technology to the proposed SPM buoy system since it cannot be reasonably be installed and operated on the source type under consideration. Therefore, traditional VRU technology is eliminated from consideration as a technically infeasible control option for BTF MACT control.

5.3.4. Selected Control Technology

TGTI has concluded that the following meet MACT under 112(g) for HAP emissions from the proposed SPM buoy system:

> *Submerged loading onto vessels which have onboard and implement a VOC management plan that complies with the requirements of MEPC.185(59).*

ATTACHMENT 1 - MEPC.185(59) - GUIDANCE FOR VOC MANAGEMENT PLANS

ANNEX 10

RESOLUTION MEPC.185(59)
Adopted on 17 July 2009

GUIDELINES FOR THE DEVELOPMENT OF A VOC MANAGEMENT PLAN

THE MARINE ENVIRONMENT PROTECTION COMMITTEE,

RECALLING Article 38(a) of the Convention on the International Maritime Organization concerning the functions of the Marine Environment Protection Committee conferred upon it by international conventions for the prevention and control of marine pollution,

NOTING that the revised MARPOL Annex VI was adopted by resolution MEPC.176(58) which is expected to enter into force on 1 July 2010,

NOTING ALSO that regulation 15.6 of the revised Annex VI requires a tanker carrying crude oil to have onboard and implement a VOC management plan approved by the Administration, and that such a plan shall be prepared taking into account the guidelines developed by the Organization,

HAVING CONSIDERED the draft Guidelines for the development of a VOC management plan prepared by the Sub-Committee on Bulk Liquids and Gases at its thirteenth session,

1. ADOPTS the Guidelines for the development of a VOC management plan, as set out in the Annex to this resolution; and

2. INVITES Governments to apply the Guidelines from 1 July 2010.

ANNEX

GUIDELINES FOR THE DEVELOPMENT OF A VOC MANAGEMENT PLAN

1 Objectives

.1 The purpose of the VOC management plan is to ensure that the operation of a tanker, to which regulation 15 of MARPOL Annex VI applies, prevents or minimizes VOC emissions to the extent possible.

.2 Emissions of VOCs can be prevented or minimized by:

.1 optimizing operational procedures to minimize the release of VOC emissions; and/or

.2 using devices, equipment, or design changes to prevent or minimize VOC emissions.

.3 To comply with this plan, the loading and carriage of cargoes which generate VOC emissions should be evaluated and procedures written to ensure that the operations of a ship follow best management practices for preventing or minimizing VOC emissions to the extent possible. If devices, equipment, or design changes are implemented to prevent or minimize VOC emissions, they shall also be incorporated and described in the VOC management plan as appropriate.

.4 While maintaining the safety of the ship, the VOC management plan should encourage and, as appropriate, set forth the following best management practices:

.1 the loading procedures should take into account potential gas releases due to low pressure and, where possible, the routing of oil from crude oil manifolds into the tanks should be done so as to avoid or minimize excessive throttling and high flow velocity in pipes;

.2 the ship should define a target operating pressure for the cargo tanks. This pressure should be as high as safely possible and the ship should aim to maintain tanks at this level during the loading and carriage of relevant cargo;

.3 when venting to reduce tank pressure is required, the decrease in the pressure in the tanks should be as small as possible to maintain the tank pressure as high as possible;

.4 the amount of inert gas added should be minimized. Increasing tank pressure by adding inert gas does not prevent VOC release but it may increase venting and therefore increased VOC emissions; and

.5 when crude oil washing is considered, its effect on VOC emissions should be taken into account. VOC emissions can be reduced by shortening the duration of the washing or by using a closed cycle crude oil washing programme.

2 Additional considerations

.1 A person in charge of carrying out the plan

.1 A person shall be designated in the VOC management plan to be responsible for implementing the plan and that person may assign appropriate personnel to carry out the relevant tasks;

.2 Procedures for preventing or minimizing VOC emissions

.1 Ship-specific procedures should be written or modified to address relevant VOC emissions, such as the following operations:

.1 Loading;

.2 Carriage of relevant cargo; and

.3 Crude oil washing;

.2 If the ship is equipped with VOC reduction devices or equipment, the use of these devices or equipment should be incorporated into the above procedures as appropriate.

.3 Training

.1 The plan should describe the training programmes to facilitate best management practices for the ship to prevent or minimize VOC emissions.

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Ref. T5/1.01

MEPC.1/Circ.680
27 July 2009

TECHNICAL INFORMATION ON SYSTEMS AND OPERATION TO ASSIST DEVELOPMENT OF VOC MANAGEMENT PLANS

1 The Marine Environment Protection Committee, at its fifty-ninth session (13 to 17 July 2009), approved the Guidelines for the Development of a Volatile Organic Compound (VOC) Management Plan for tankers carrying crude oil (resolution MEPC.185(59)).

2 In conjunction with consideration of the guidelines, MEPC 59 agreed that additional technical information on vapour pressure control systems and their operation would assist the industry in development of VOC management plans. Therefore, MEPC 59 agreed to the technical information on systems and operation to assist development of VOC management plans for tankers carrying crude oil, as set out in the annex to this document.

3 The technical information addresses the general equipment and systems involved, their operation and conditions on board a crude oil tanker with respect to the formation and emission of Volatile Organic Compounds (VOC) as well as the ability to control VOC formation and emissions.

4 Member Governments are invited to bring this circular to the attention of their Administrations, relevant shipping organizations, recognized organizations, shipping companies and other stakeholders concerned and encourage them to take it into account when applying the Guidelines for the development of a VOC management plan for crude oil tankers.

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ANNEX

TECHNICAL INFORMATION ON VAPOUR PRESSURE CONTROL SYSTEMS AND THEIR OPERATION TO ASSIST DEVELOPMENT OF VOC MANAGEMENT PLANS FOR TANKERS CARRYING CRUDE OIL

Introduction

This technical information is compiled pursuant to the requirements in MARPOL Annex VI Regulation 15.6, and describes the general equipment, operations and conditions onboard a crude oil tanker with respect to the emission and ability to control Volatile Organic Compound (VOC) emissions.

The Guidelines for the development of a VOC management plan state:

1 Objectives

.1 The purpose of the VOC management plan is to ensure that the operation of a tanker, to which regulation 15 of MARPOL Annex VI applies, prevents or minimizes VOC emissions to the extent possible.

.2 Emissions of VOCs can be prevented or minimized by:

.1 optimizing operational procedures to minimize the release of VOC emissions; and/or

.2 using devices, equipment, or design changes to prevent or minimize VOC emissions.

.3 To comply with this plan, the loading and carriage of cargoes which generate VOC emissions should be evaluated and procedures written to ensure that the operations of a ship follow best management practices for preventing or minimizing VOC emissions to the extent possible. If devices, equipment, or design changes are implemented to prevent or minimize VOC emissions, they shall also be incorporated and described in the VOC management plan as appropriate.

.4 While maintaining the safety of the ship, the VOC management plan should encourage and, as appropriate, set forth the following best management practices:

.1 the loading procedures should take into account potential gas releases due to low pressure and, where possible, the routing of oil from crude oil manifolds into the tanks should be done so as to avoid or minimize excessive throttling and high flow velocity in pipes;

.2 the ship should define a target operating pressure for the cargo tanks. This pressure should be as high as safely possible and the ship should aim to maintain tanks at this level during the loading and carriage of relevant cargo;

.3 when venting to reduce tank pressure is required, the decrease in the pressure in the tanks should be as small as possible to maintain the tank pressure as high as possible;

.4 the amount of inert gas added should be minimized. Increasing tank pressure by adding inert gas does not prevent VOC release but it may increase venting and therefore increased VOC emissions; and

.5 when crude oil washing is considered, its effect on VOC emissions should be taken into account. VOC emissions can be reduced by shortening the duration of the washing or by using a closed cycle crude oil washing programme.

2 Additional considerations

.1 A person in charge of carrying out the plan

.1 A person shall be designated in the VOC management plan to be responsible for implementing the plan and that person may assign appropriate personnel to carry out the relevant tasks;

.2 Procedures for preventing or minimizing VOC emissions

.1 Ship-specific procedures should be written or modified to address relevant VOC emissions, such as the following operations:

.1 Loading;

.2 Carriage of relevant cargo; and

.3 Crude oil washing;

.2 If the ship is equipped with VOC reduction devices or equipment, the use of these devices or equipment should be incorporated into the above procedures as appropriate.

.3 Training

.1 The plan should describe the training programmes to facilitate best management practices for the ship to prevent or minimize VOC emissions.

Section 1 – The hull and its pressure limitations

1.1 Allowable cargo tank ullage pressure

1.1.1 The cargo tank structure is designed to withstand a range of design loads and parts of the tank structure will also contribute to the global longitudinal strength of the ship. The classification societies' specified load conditions and loads are applied in verification of the structural design. One such load is the combined pressure from the liquid cargo and the tank ullage pressure. The tank ullage pressure is to be minimum 25 kN/m^2 or the opening pressure of the pressure relief device (P/V valve), whichever is greater. Accordingly, the maximum allowable ullage pressure in a standard tanker is typically interpreted as 25 kN/m^2 (i.e. approximately 2,550 mmWG). It should however be noted that global strength considerations and the impact of other design loads may imply that actual allowable pressure could be higher.

1.1.2 In terms of under pressure, SOLAS regulation II-2/11.6 indicates an allowable under pressure of -700 mmWG. From a structural point of view, the maximum allowable tank under pressure is presumably lower.

1.1.3 Exceeding the maximum allowable pressures could lead to structural failures. If such a structural failure results in opening of the tank structure to atmosphere, uncontrolled VOC emissions will occur together with the possibility of oil pollution to the seas. Further, it could result in loss of inert gas protection with subsequent hazards related to fire and explosion.

1.2 Typical cargo tank venting systems

1.2.1 The design of cargo tank venting and inert gas systems is governed by SOLAS regulation II-2/11.6 and 5. Most crude oil tankers have a common cargo tank venting and inert gas main pipeline which is also used for vapour emission control (ref. section 4). Branches to each cargo tank are provided with isolation valves and blanking arrangements. The isolation valves and blanks are typically only used in connection with tank entry. SOLAS chapter II-2 requires that the isolation valves are to be provided with locking arrangements to prevent inadvertent closing/opening of said tanks. The cargo tank venting/inert gas main is connected to a mast riser. The mast riser has a minimum height of 6 metres with an IMO approved flame arrestor at its outlet. An isolation valve is provided between the cargo tank venting/inert gas main and the mast riser. Some designs have a small capacity pressure/vacuum valve fitted in a bypass across the isolation valve. This latter enables thermal breathing from cargo tanks when the isolation valve is closed. A liquid-filled P/V breaker is typically connected to the cargo tank venting/inert gas main. The P/V breaker has a capacity to accommodate the gas flow from cargo tanks during loading (125% of the loading rate and discharge rate). The cargo tank venting/inert gas main is typically used during loading and discharging operations. During loading the mast riser valve is open (unless vapour emission control is performed) and VOC is expelled to air. During discharge the same valve is closed and inert gas used to replace the tank atmosphere. The cargo tank venting/inert gas main is also used during voyage but the mast riser valve will be operated only in the event of increasing ullage pressure.

1.2.2 In addition to the common cargo tank venting/inert gas main, each cargo tank is required to have a pressure/vacuum relief device for thermal breathing in the event the cargo tank is isolated from the common cargo tank venting/inert gas main. Although classification societies accept that these devices have the capacity to accommodate gas volumes resulting from variations in cargo temperature only (i.e. thermal breathing), latest industry practices have led to the installation of devices with the capacity to accommodate the full gas flow from loading of cargo tanks.

1.3 **Typical settings of pressure/vacuum relief devices**

1.3.1 Although the design pressure of cargo tanks is typically +2,500 mmWG and -700 mmWG, the typical setting of pressure/vacuum valves on crude tankers is +1,400 mmWG and -350 mmWG.

1.3.2 The typical settings of the P/V breakers are +1,800 mmWG and -500 mmWG. It should be noted that for liquid filled P/V breakers, the settings have to take into account ship movement (rolling and pitching) as specified by the classification societies.

Section 2 – Crude Oil Tanker Pressure control/release systems

2.1 **Introduction**

2.1.1 Traditionally, vapour release from crude oil tankers occurs on three discrete occasions, they being: during loading, during the loaded voyage to the discharge port, and during the ballasting of cargo tanks at the discharge port.

2.1.2 Since the introduction of the International Convention for the Prevention of Pollution from Ships together with its Protocol in 1978 (MARPOL), tankers built after 1 June 1982 (regulation 18), termed MARPOL tankers, are all designed with the required totally segregated (designated) ballast tanks. With these regulations in force, cargo tanks are never used for the loading of ballast, except on very rare occasions for bad weather purposes where one of the Crude Oil Washed cargo tanks is dedicated to take in ballast water. Therefore, the displacement of vapour from the relevant crude oil cargo tank at the discharge port has ceased to occur for the MARPOL compliant type tankers. Given this situation then, only two occasions remain where vapour emissions from crude oil tankers generally occur, namely on loading and during the transportation of the cargo.

2.2 **Load Port Displacement of VOC**

2.2.1 Displacement of crude oil cargo vapours at the loading port continues to occur. The reasons for the existence of these volumes of this displaced, but co-mingled[1], vapour must be subdivided and attributed to two discrete tanker operations; namely existing vapour in the cargo tank system before loading and, the evolved vapour created during the loading programme.

2.2.2 The first portion of the vapour displaced from the cargo tanks to be considered is that from the evolved vapour generated during the previous discharge programme and in particular that vapour generated as a result of the Crude Oil Washing of the cargo tanks. The concentration of this proportion of vapour within the co-mingled gas mixture within a cargo tank can be

[1] The vapour emissions on loading are a mixture of hydrocarbon vapours and the inert gas introduced into the cargo tank to achieve a positive pressure within the cargo tank system.

determined prior to commencement of the loading process. The second portion of vapour displaced is that that develops or evolves during the loading programme itself. This vapour evolves as a result of, both, the turbulence generated in the cargo tanks due to the volumetric rate of loading and the pressure differentials within the loading pipeline system creating a degree of "flashing" of the vapour from the incoming crude oil.

2.2.3 To illustrate the extent of these gases within a cargo tank system on a tanker during a loading process, Figure 2.1 below shows the measurements of hydrocarbon vapour concentrations as taken from a tanker during its loading programme. The "X" axis of the graph records the percent status of loading of the tanker whereas the "Y" axis records the percentage of hydrocarbon vapour (VOC) concentration. The graph primarily records the total hydrocarbon gas concentration at the differing percentages of loading of the cargo tanks. However, this total figure is then mathematically proportioned and subdivided, taking into consideration the diminishing size of the vapour volume in the cargo tanks, into the two concentrations of vapours, namely those present at the commencement of loading (in the event approximately 4% of the total tank vapour volume) and the concentration of vapours that evolve as a result of the loading process.

2.2.4 These vapours are displaced by the incoming cargo volumes, throughout the loading period, and released through the ship's vapour pipeline system (inert gas pipeline) to atmosphere via the ship's mast riser. In order to prevent excess pressures within the cargo tank system the isolation/control valve to the mast riser is fully opened at the commencement of loading and remains opened until completion of loading. Once the mast riser valve is shut and loading is completed, the necessary "in tank" positive pressure is achieved to prevent any form of air/oxygen entry into the cargo tank vapour system as is required by the SOLAS regulations.

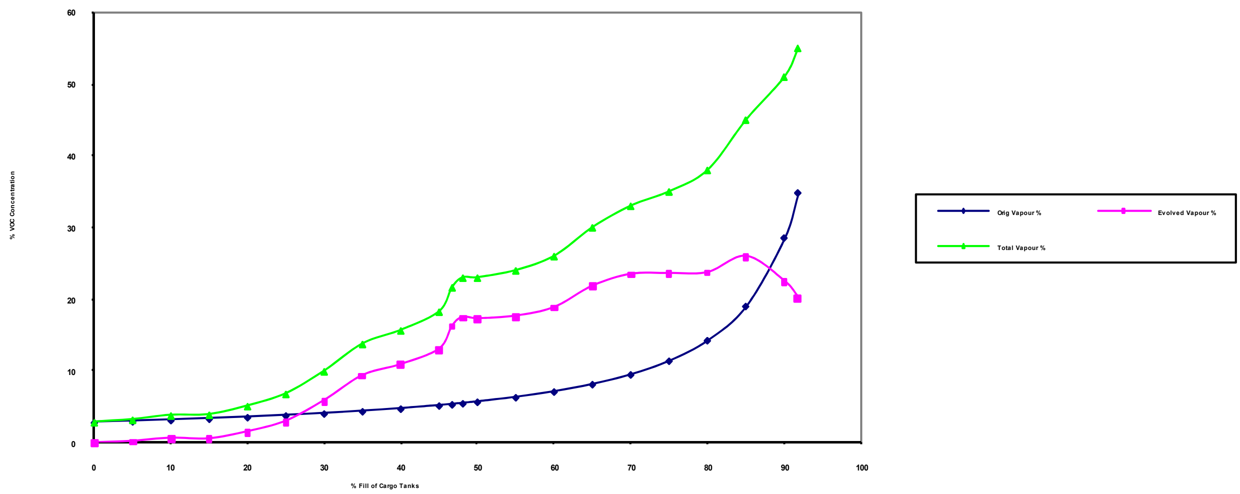

Figure 2.1 – Hydrocarbon vapour concentration in the vapour phase during a loading

2.2.5 In Figure 2.2 below, a photograph shows the deck of a tanker and highlights the relevant pressure control and release mechanisms, namely the vessel's mast riser, the individual tank Pressure/Vacuum (P/V) valves and the secondary safety mechanism of the P/V breaker. These mechanisms will be explained further in this section.

Figure 2.2 – Main Cargo Deck of a Crude Oil Tanker

2.2.6 Typically a normal loading programme will take about 24 hours for a VLCC with a volumetric rate of loading of up to 20,000 m^3/hour. The mast riser is normally used during loading for tank vapour pressure control. Its exit location, being at least 6 metres above the deck, allows for the free flow of the vapours displaced from the cargo tanks by the incoming liquid crude oil at the rate of loading of the cargo. The rate of displacement of VOC vapours from the cargo tank system will be the same as the loading rate but the concentration of VOC vapours in the displaced stream will be greater dependent upon the extent and rate of evolution of VOC vapours (vapour growth) from the incoming cargo that would add to the volume of gas/vapour mixture already existent in the cargo tank prior to loading, as shown in Figure 2.1 above.

2.3 **VOC release during the voyage**

2.3.1 During the voyage, the temperature of the gases/vapours in the ullage space of the cargo tanks and the liquid cargo varies. The gas phase consists of a mixture of unsaturated gases (Inert Gas – for tank safety and protection) and saturated vapours (evolved hydrocarbon vapours from the cargo). The temperature of the gas phase of the tank varies diurnally with its maximum temperature being achieved by mid afternoon and its coolest temperature in the early hours of the morning. The liquid phase temperature varies very much slower and is dependent upon both the hull design and the temperature of the surrounding seawater.

2.3.2 Figure 2.3 below records, as an example, the vapour pressure and cargo temperature data of a reported voyage for a single hulled (but segregated ballast) tanker. The graph records on the "X" axis the days of the voyage whereas the "Y" axis records both the cargo temperature (^{o}C) and the pressure (mmWG) within the vapour phase of the cargo tank system. Superimposed upon the graph is both the normal operational release pressure as well as the P/V valve opening pressure levels. The vapour pressure readings were recorded every four hours whereas the cargo liquid temperature readings (blue) were recorded daily.

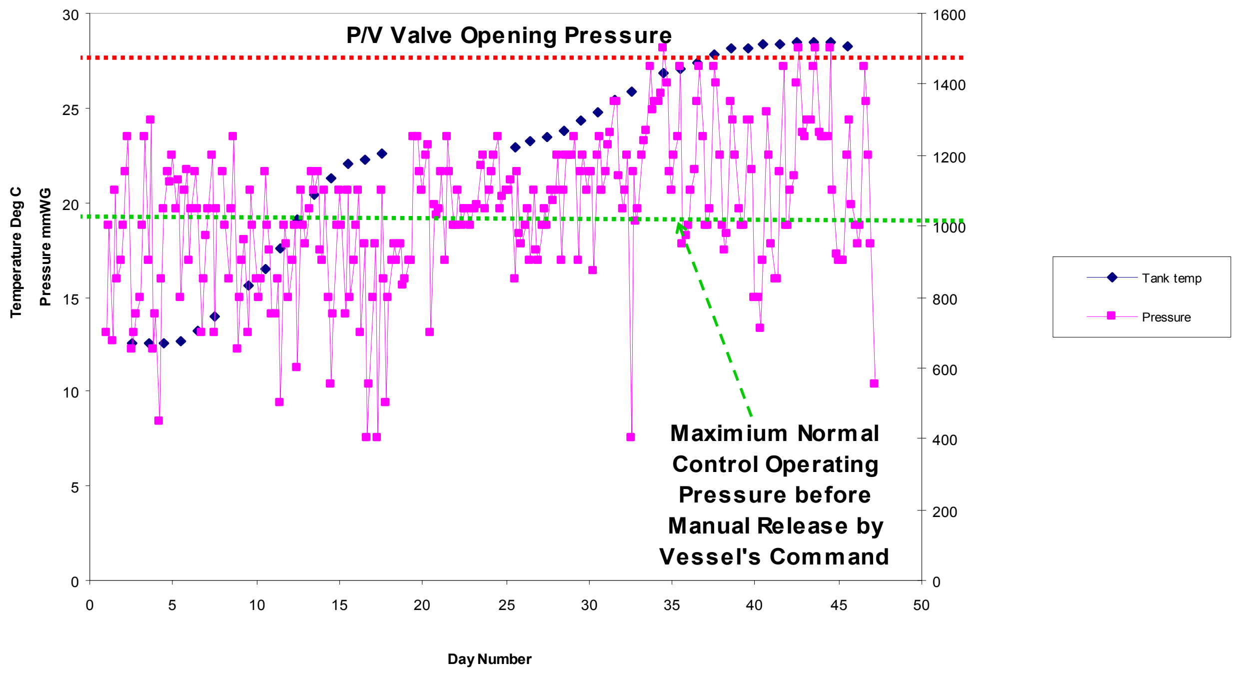

Figure 2.3 – Temperature and Pressure profile for a crude oil voyage

2.3.3 The double hulled construction of a crude oil tanker has a void/ballast space located between the cargo tank and the outer hull, this causes the temperature of the liquid cargo to remain closer to the temperature of the cargo upon loading for a longer period due to the so called "Thermos Effect" or heat loss insulation created by the void or empty ballast space. The cargo temperature profile, as shown in Figure 2.3, reflects the expected changes to temperature for a cargo carried on board a single hulled vessel where the impact of the seawater temperature upon the cargo is more apparent. This aspect can be more clearly seen in Figure 2.3 for the early/interim days of the 47-day voyage from North Sea to the Far East.

2.4 A Crude Oil Tanker's vapour pressure control mechanisms

2.4.1 A crude oil tanker is designed and constructed to withstand high vapour pressures up to a certain value. In order to protect the vessel's structure against excessive pressures, two differing levels of safety mechanisms are installed to control and limit the pressures exerted in the vapour phase of the cargo system. The installation of both these systems is a requirement within the International Convention for the Safety of Life at Sea (SOLAS). These mechanisms are:

.1 the individual tank Pressure/Vacuum (P/V) valve; and

.2 the common Pressure/Vacuum (P/V) breaker.

2.4.2 The P/V valve is the primary mechanism for the protection from cargo tank over pressure. The design and operational requirements of the P/V valves are set out in the ISO 5364:2000 standard but the opening and closing pressure setting of the individual valves is set in accordance with the designed tolerance of the relevant structure having applied the necessary safety margins.

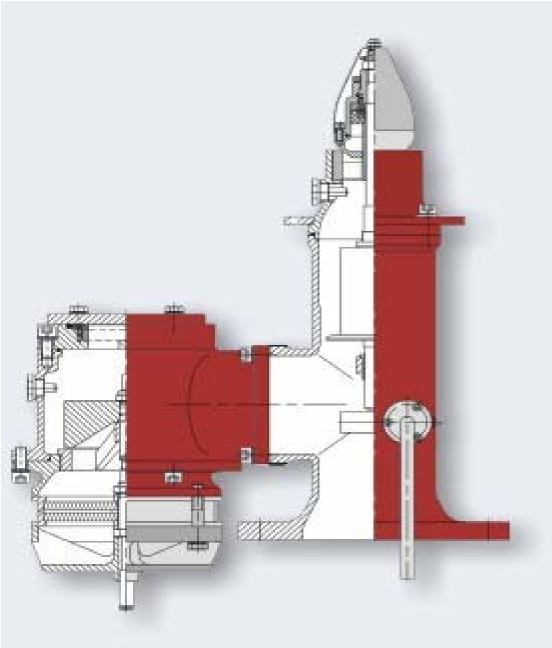

Figure 2.4 – A design and construction of a P/V valve[2]

2.4.3 A design of a P/V valve may be seen in Figure 2.4 above. The valve is fitted to a vertical pipeline connected directly to the vapour space of a cargo tank (see Figure 2.2 above). The valve consists of two sections, namely the vacuum protection section on the left hand side of the valve as shown and the pressure control mechanism of the right hand side. Both mechanisms rely upon a weighted diaphragm that will be lifted when the pre-designed pressures are met. On the pressure side of the valve the exit nozzle is designed such that the exit velocity of the vapours reach the required velocity so as to maintain the deck working area clear of hydrocarbon vapours.

2.4.4 Each cargo tank is normally equipped with its valve so that full protection is available, should the individual cargo tank be isolated from the main common vapour system on board the tanker. The typical pressure setting for a P/V valve is traditionally measured in millimetres of water gauge and would be in the range from 1,400 to 1,800 mmWG. These valves are supported on a connecting pipeline to the tank's atmosphere by a 100 to 150 mm diameter pipeline and located at least 2 metres above the deck. Due to the requirements to prevent mechanical damage to these valves the closing pressure is controlled by a damping mechanism (to prevent hammering of the valve). As a result of the damping mechanism the closing pressure of the valve will vary but will be in the range of 400-800 mmWG.

2 Courtesy Pres-Vac Engineering A/S: www.pres-vac.com.

2.4.5 Supporting the over pressure safety system of the P/V valve is the secondary safety mechanism of the P/V breaker. In the event of a rapid pressure fluctuation within the common vapour system the P/V breaker is available to relieve such an over pressure. The single P/V breaker is located on the common vapour pipeline, serving all the cargo tank branch pipelines, which ends at the vessel's mast riser (see Figure 2.2).

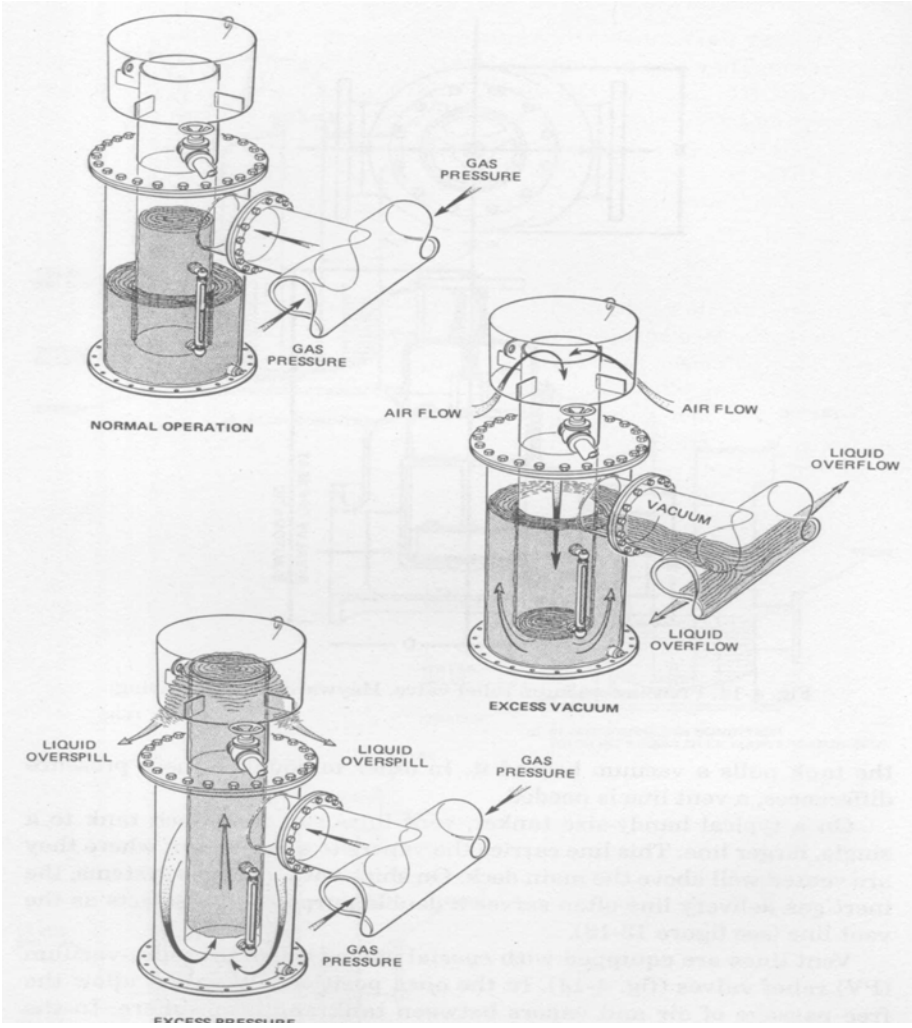

Figure 2.5 – The design and operation of a P/V breaker[3]

2.4.6 The construction and operation of the P/V breaker may be seen in Figure 2.5 above. The pressure setting in the P/V breaker is achieved by way of the internal water column with an equivalent pressure setting of approximately 2,000 mmWG. The water column also isolates the vapour phase from external air ingress into the system. In the event of an excessive pressure surge within the tank vapour system the water column would either be displaced out of the breaker onto the deck, in the event of excessive pressure, or drawn into the cargo tanks in the event of an under pressure. This will, therefore, open the total vapour system to the external environment and atmospheric pressure and, due to the equipment's dimensions, will relieve the pressure in the system very quickly. Thus, this safety mechanism, due to its pressure setting, will only operate if the vessel tank's P/V valves fail to operate or are not of sufficient capacity to relieve the pressure surge adequately.

3 Reference – G.S. Marton, Tanker Operations – a Handbook for Ship's Officers, page 76.

2.4.7 It should, however, be noted that once the P/V breaker operates then, as stated above, it will reduce the pressure within the tank vapour system to atmospheric pressure, thereby exposing the tank system to ingress of oxygen. Therefore, this system is a "last resort" system to preserve the structure of the tanker from damage.

Section 3 – VOC generation systems in Crude Oil

3.1 Why limit VOC Emissions to the atmosphere? VOCs are a pollutant to the air and act as a precursor to the formation of Tropospheric Ozone – commonly termed Smog.

Thus, to control this emission, there are four criteria that impact on the extent and rate of evolution of gaseous VOC from crude oils and its subsequent release to atmosphere. These are:

.1 the volatility or vapour pressure of the crude oil;

.2 the temperature of the liquid and gas phases of the crude oil tank;

.3 the pressure setting or control of the vapour phase within the cargo tank; and

.4 the size or volume of the vapour phase within the cargo tank.

Each of these criteria are defined and briefly explained below together with any interaction between the criteria for general operational circumstances.

3.2 The volatility or vapour pressure of the crude oil

3.2.1 Reid Vapour Pressure (RVP) – this is an industrially developed standard test method to determine the Air Saturated absolute Vapour Pressure of volatile, non-viscous hydrocarbon liquids in compliance with the requirements specified in the Institute of Petroleum test procedure IP 69.

3.2.2 The RVP is the vapour pressure obtained within a standardized piece of test equipment for the evolved hydrocarbon vapour at a temperature of 100ºF or 37.8ºC. The standard test parameters for the determination of this pressure are important to identify and relate to the ratio of a fixed liquid volume to a fixed vapour volume. This ratio is one part liquid to four parts vapour. Thus, the pressure reported for this parameter reflects, in principle, the pressure that would be registered when the cargo tanks are about 20% loaded.

3.2.3 This leads to the importance of two other parameters, namely the Saturated Vapour Pressure and Unsaturated Vapour Pressure. These two parameters, and the physics behind them, give more clear indications and guidance with respect to a crude oil's volatility with respect to vessel operations and VOC control.

3.2.4 Saturated Vapour Pressure (SVP)[4] – is the equilibrium pressure generated by the liquid phase for the vapour volume within a defined system. The Saturated Vapour Pressure is developed only by the evolved hydrocarbon vapours from the crude oil liquid phase. For a Saturated Vapour to be present it must have contact with its own liquid phase. If the liquid phase temperature

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4 An empirical equation exists to correlate the Reid Vapour Pressure (psia) to the Saturated Vapour Pressure of a crude oil at the constant temperature of 37.8°C. This equation is: $\mathbf{P = (6.2106^{*} \ Ln\ P_R) + 4.9959}$; Where P is the Saturated Vapour Pressure (psia) at 37.8°C and P_R is the Reid Vapour Pressure (psia) at the same temperature.

increases or decreases so will the Saturated Vapour Pressure vary accordingly – an increase the liquid temperature will cause an increase in the Saturated Vapour Pressure.

3.2.5 However, if the vapour volume increases or decreases for a known liquid temperature, the pressure should, in theory, remain constant (for further understanding on this parameter see paragraph 3.5.2 below). These circumstances, respectively, will only cause the vapour to condensate and fall back to the liquid phase or more vapour to evolve from the liquid phase to maintain the Saturated Vapour Pressure. This physical characteristic is indicative of equilibrium pressure – between the liquid and vapour phases within the defined system.

3.2.6 From the foregoing it can be readily recognized that Saturated Vapour Pressure should not vary with the size of the vapour volume and will only vary with the temperature of the liquid phase – not the vapour phase temperature.

3.2.7 Unsaturated Vapour Pressure (UVP) – contrary to the concept of Saturated Vapour Pressure, an Unsaturated Vapour is not in contact with its liquid phase. In this case the vapour is obtained from other sources such as air or, more likely, Inert Gas. Thus, by reference to the standard laws of physics and what is termed the Ideal Gas Law[5], both variations in volume and/or temperature (this time it is the gas or vapour phase) will vary the pressure within a closed system.

3.2.8 From an operational perspective this type of behaviour is the primary cause of the variation of pressures within a cargo tank system over a 24-hour period and is to be associated with the Inert Gas phase within a cargo tank. However, the pressure generated from this type of gas/vapour is not the total vapour pressure in the cargo system.

3.2.9 Behind the pressure generated from the Unsaturated Vapours (Inert Gas) lies the pressure generated by the Saturated Vapours (the hydrocarbon vapours evolving from the crude oil cargo). As stated above, this pressure will remain as a constant for a given cargo/liquid temperature and, as is well recognized, a cargo temperature will not vary to the same extent as the vapour temperature due to heating or cooling from external sources (sunlight, sea temperature, air temperature, etc.). Thus, the variation for the tank observed Total Vapour Pressure is due to the presence of Inert Gas in the cargo tank.

3.2.10 Total Vapour Pressure – this pressure is the total pressure to be achieved within a defined closed system given the variable parameters of vapour volume and the differing control temperatures. In fact it is the combination or addition of the Saturated and Unsaturated Vapour Pressures (Dalton's Law of Partial Pressure[6]) within a closed and defined system.

3.2.11 Thus, on board a tanker, the pressure measured within Vapour System is the Total Vapour Pressure of the system which is the sum of the two individual pressures generated by the differing types of gases present in the system.

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5 The Ideal Gas Law equation is **PV = nRT** or **P = (nRT)/V** where: P = Pressure, T = Temperature, V = Volume and nR are gas constants.

6 Dalton's Law of Partial Pressure states that "The pressure of a mixture of gases is the sum of the partial pressures of its constituents".

3.3 The temperature of the crude oil in a cargo tank

3.3.1 The measurement and determination of temperature upon the two differing phases in a crude oil cargo tank have differing impacts upon the size and extent of pressure exerted at any one time in the cargo tank. In this regard it is necessary to consider the two phases separately with regard to the impact of temperature.

3.3.2 The temperature of the liquid in a crude oil cargo tank – the temperature of the liquid phase in a crude oil cargo tank will vary little over the period of a voyage unless cargo heating is being undertaken. It is this temperature that determines the Saturated Vapour Pressure that will be exerted by the evolving VOCs from the cargo volume and contribute to the Total Vapour Pressure in the cargo tank at any one time. The cooler the liquid phase temperature the lower will be the Saturated Vapour Pressure of the crude oil but care should be taken not to allow cooling of waxy cargoes too much, such that it promotes wax precipitation.

3.3.3 The temperature of the vapour or gas in a crude oil cargo tank – the temperature of the gas phase in a cargo tank will change more rapidly and vary during the day/night cycle. As this phase in the cargo tank contains a mixture of Saturated (evolved hydrocarbon gases) and Unsaturated (Inert gas) gas species the pressure in this space will vary with temperature due to the reaction of the Unsaturated Gas component to temperature (Ideal Gas Law[5]). Thus, during the day when the gas phase warms, the pressure in the tank will increase so long as there is an Inert Gas component in the gas phase. The obverse will occur at night as the gas phase cools.

3.4 The pressure setting or control of the vapour phase within the cargo tank

3.4.1 The technologies available on board crude oil tankers for the control of pressure within the cargo tank vapour system are discussed in section 2. However, it is important to identify the significance of pressure with respect to the evolution of hydrocarbon vapours from a crude oil liquid phase.

3.4.2 Control of the extent of the pressure within a crude oil cargo tank vapour system will determine the extent of further vapour evolution from a crude oil cargo. If the pressure within the system is controlled at the Saturated Vapour Pressure of the cargo, then equilibrium pressure between the liquid and vapour phase is obtained and no further VOC will evolve from the cargo. However, if the vapour pressure in the crude oil tank vapour system is reduced to a pressure below the Saturated Vapour Pressure of the cargo, then VOC will evolve to restore the equilibrium balance in the system.

3.5 The size or volume of the vapour phase within the cargo tank system

3.5.1 The size or volume of the gas or vapour phase in the cargo tank system (usually a common system on a crude oil tanker due to the interconnection through the Inert Gas pipeline system) is an important criterion to establish the pressure within the system. Again separate consideration should be given to the two differing types of gases to be found in the vapour phase and how volume may impact these component gases.

3.5.2 Saturated vapours from the crude oil liquid phase, as described above in paragraph 3.2.2, under theoretical conditions the pressure generated by saturated vapours will not be affected by a change in the volume space occupied by the vapours. However, due to the numerous species of hydrocarbon types to be found in evolved vapour from a crude oil it has been found that a volumetric change of the vapour phase from a 2% volume (V:L ratio of 0.02) to a 20% volume

(V:L ratio 0.2) will impact the saturated vapour pressure of a crude oil at a constant temperature. For vapour volumes greater than 20% of the total volume the pressure behaves similar to that expected of a Saturated Vapour; namely nearly isobaric. These circumstances can be seen in Figure 3.1 below for a selection of crude oil types.

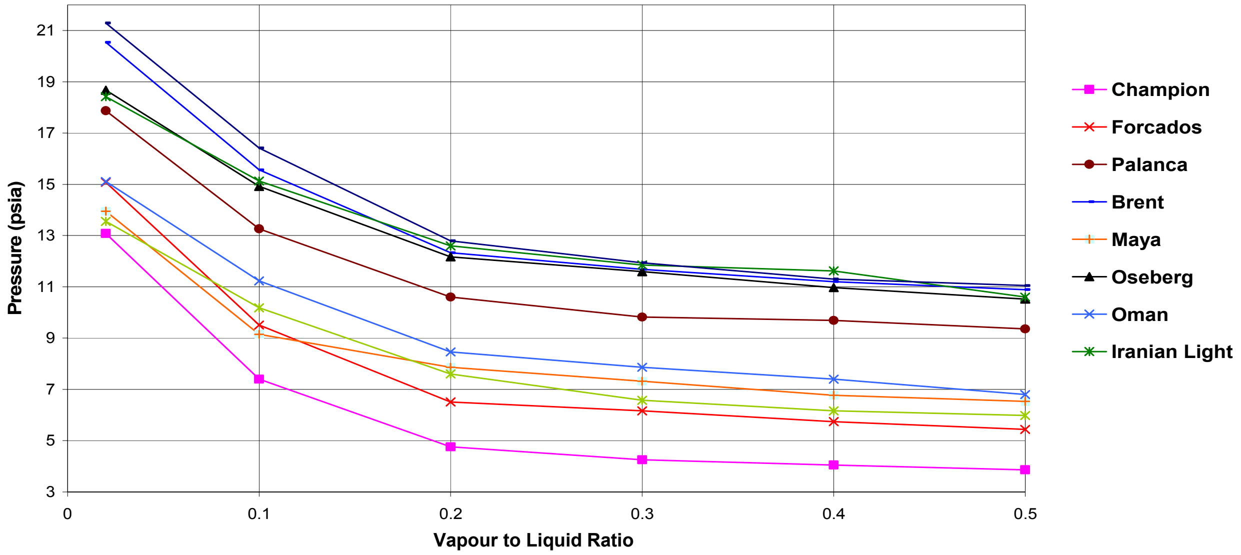


Figure 3.1

3.5.3 The change in pressure with respect to volume, for a vapour percent volume from 2% to 20%, for complexed vapour phases evolved from crude oils, is due to the influence of the individual volatile hydrocarbon types and their varying proportions in both the liquid and vapour phase that separately contribute to the final saturated vapour pressure under equilibrium conditions. The ratio of concentration of the individual hydrocarbon compounds in the vapour phase is due to the *Partition Coefficients* for each hydrocarbon type in relation to another type. This will cause a differing distribution of hydrocarbon species to that in the liquid phase when the vapour phase volume is smaller.

3.5.4 Unsaturated gases (Inert Gas) in the vapour phase system – this type of gas behaves in a manner simulated by the Ideal Gas Law equation[5]. Therefore any reduction in the volume occupied by this gas will cause an increase in the pressure exerted by the gas at a known temperature.

Section 4 – Methods and systems for the control VOC

In this section, examples of methods and systems for the control of VOC are provided.

4.1 Methods and systems for the control of VOC during Loading

4.1.1 Best Practices and design

.1 Manual pressure relief procedures (tank pressure control);

.2 P/V valve condition and maintenance;

.3 Condition of gaskets for hatches and piping;

.4 Inert gas topping up procedures;

.5 Partially filled tanks;

.6 Loading sequence and rate; and

.7 Use of vapour return manifold and pipelines when shore facilities are available.

4.1.2 **Vapour Emission Control Systems**

The principle behind VECS is that VOC generated in cargo tanks during loading is returned to the shore terminal for processing, as opposed to being emitted to atmosphere through the mast riser.

Vapour Emission Control Systems (VECS) were introduced in 1990 as a requirement for tankers loading oil and noxious liquid substances at terminals in the United States (USCG 46 CFR Part 39). IMO followed up with the introduction of IMO MSC/Circ.585 "Standards for vapour emission control systems" in 1992. International regulation requiring vapour emission control was introduced through regulation 15 of MARPOL Annex VI adopted in 1997, although it is only required for ships loading cargo at terminals where IMO has been informed that VECS is mandatory.

Since 1990, most crude tankers have installed a VECS system in compliance with USCG regulations. The regulations cover both the technical installation (vapour recovery piping and manifold, vapour pressure sensors and alarms, level gauging, high level and independent overflow alarms) as well as operational restrictions and training. The operational restrictions are found in a mandatory VECS manual which also includes maximum allowable loading rates. The maximum allowable loading rate is limited by one of the following:

.1 the pressure drop in the VECS system from cargo tank to vapour manifold (not to exceed 80% of the P/V valve setting);

.2 the maximum pressure relief flow capacity of the P/V valve for each cargo tank;

.3 the maximum vacuum relief flow capacity of the P/V valve for each cargo tank (assuming loading stopped while terminal vacuum fans are still running); and

.4 the time between activation of overfill alarm to relevant cargo tank being full (min. 1 minute).

The calculations are to be based on maximum cargo vapour/air densities as well as maximum cargo vapour growth rates, which again may limit the cargoes that can be loaded with VECS.

Further, the calculations are to be carried out both for single tank and multiple tank loading scenarios.

The USCG regulations also contain additional requirements to vapour balancing, i.e. for tankers involved in lightering operations. These include operational requirements as well as technical requirements for an in-line detonation arrestor, oxygen sensors with alarms and possibly means to prevent hazards from electrostatic charges.

For ships provided with a VECS system as per IMO or USCG regulations, the control of VOC emissions will be through returning VOC to the shore terminal in accordance with the procedures found in the onboard VECS manual.

The maximum allowable loading rates and corresponding maximum vapour/air densities and vapour growth rates should be specified in the VOC management plan.

4.1.3 **Vapour Pressure Release Control Valve (VOCON valve)**

The VOCON valve operates as a hydraulically controlled valve that controls the closing pressure for the valve and therefore undertakes a similar procedure to the manual VOCON procedure as described in 4.2.2 below. However, for the loading programme, the valve also allows a higher pressure to be maintained throughout the loading process in order to limit the extent of vapour evolution from the crude oil once saturated vapour pressure is achieved within the tank vapour system. This valve is normally a single valve facility and located at the bottom of the mast riser by way of a by-pass pipeline to the mast riser control valve. The relevant closing pressure setting for the valve may be done locally or remotely in the Cargo Control Room depending upon the sophistication of the installed system.

Figure 4.1 – Hydraulically controlled VOCON valve

Similar valves with fixed pressure arrangements are to be found and are currently installed on tankers and located at the same position; namely at the bottom of the mast riser by way of a by-pass pipeline to the mast riser control valve. These valves operate as a form of “tank breather” valve but release vapour through the mast riser.

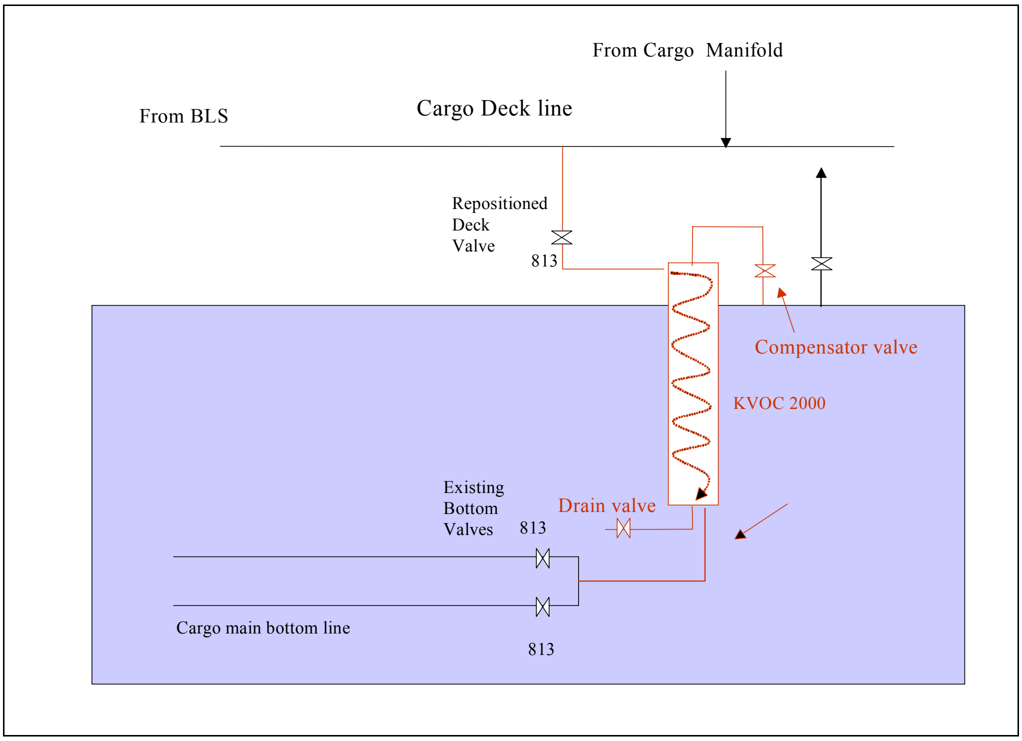
4.1.4 **Cargo Pipeline Partial Pressure control system (KVOC)**

The purpose of the KVOC system installation is to minimize VOC release to the atmosphere by preventing the generation of VOC during loading and transit. The basic principle of KVOC is to install a new drop pipeline column specially designed for each tanker with respect to expected loading rate. The new drop pipeline column will normally have an increased diameter compared to an ordinary drop line. The increased diameter will reduce the velocity of the oil inside the column and by that means ensure that the pressure adjusts itself to approximately the boiling point of the oil independent of the loading rate. In the initial phase of the loading process some VOC might be generated. The pressure inside the column will adjust itself to the SVP of the oil so that there is a balance between the pressure inside the column and the oil SVP. When this pressure has been obtained in the column the oil will be loaded without any additional VOC generation. This means that KVOC column prevents under pressure to occur in the loading system during loading.

The KVOC system is not designed to remove all VOC, but to minimize generation of VOC. VOC remaining in the tanks from the last cargo and COW operations has to be displaced from the cargo tanks when loading. Also, if the oil boiling point (SVP) is higher than the tank pressure, some crude oil will generate VOC in the tanks and additional VOC be released. Bad weather together with very volatile oil will also increase the VOC emissions due to its SVP also when KVOC is applied.

The KVOC column has an effect on the VOC release during transit, because gas bubbles have been prevented from forming. This means that the amount of gas bubbles in the oil available for release during transit will be minimized. To further reduce the release of VOC, the pressure in the cargo tanks should be held as high as possible. A high pressure, from about 800 to 1,000 mmWG, will reduce possible boiling and diffusion of VOC in the crude oil cargo tanks.

KVOC has also shown a similar effect on H_2S as on minimizing VOC generation. If the KVOC system has been installed, it should therefore always be used when loading sour crude to minimize H_2S concentration in the void spaces and release during loading and transit.



Pipeline Flow Plan for KVOC

4.1.5 **Increased pressure relief settings** ***(Applicable also for transit conditions)***

As described in sections 2 and 3, as long as the tank pressure is maintained above the Saturated Vapour Pressure of the cargo, then equilibrium is obtained between the liquid and vapour phase of the cargo and no further VOC will evolve from the cargo. This means that if the pressure/vacuum relief settings are increased to, e.g., 2,100 mmWG, VOC will not evolve from a cargo as long as the Saturated Vapour Pressure of said cargo is below the pressure relief setting.

As indicated earlier, the maximum design pressure of a cargo tank is at least 2,500 mmWG and, as such, increasing the settings of the pressure/vacuum devices up to, e.g., 2,100 mmWG, should not require additional strengthening. It will however require adjustment/replacement of P/V valves. Note that for some P/V valves designs, the pressure after initial opening increases, and this has to be taken into account if an owner intends to increase the setting of P/V valves.

Needless to say it will also require replacement/modifications to the P/V breaker, as well as water loops serving the inert gas deck water seal, as well as settings of pressure sensors and alarms in the inert gas and VECS system. It is of course also essential that onboard operational procedures in terms of manual pressure release have to be adjusted.

One additional benefit is that increasing the pressure/vacuum relief settings will increase the acceptable loading rate during VECS.

Although the primary benefit of increasing set pressure will occur during voyage. It will also have an effect related to loading, as the increased set pressure will limit the existing vapour in the cargo tanks, i.e. the vapour generated during the previous discharge and Crude Oil Washing.

For ships that have been provided with increased pressure relief settings, the VOC emissions will be controlled when the saturated vapour pressure of the crude oil is below that of the pressure relief valve settings.

It is important that terminals and cargo surveyors acknowledge that if ships with higher pressure settings are required to de-pressurize prior to cargo handling operations, this will limit the ships' ability to control VOC emissions.

4.1.6 **Vapour recovery systems – General**

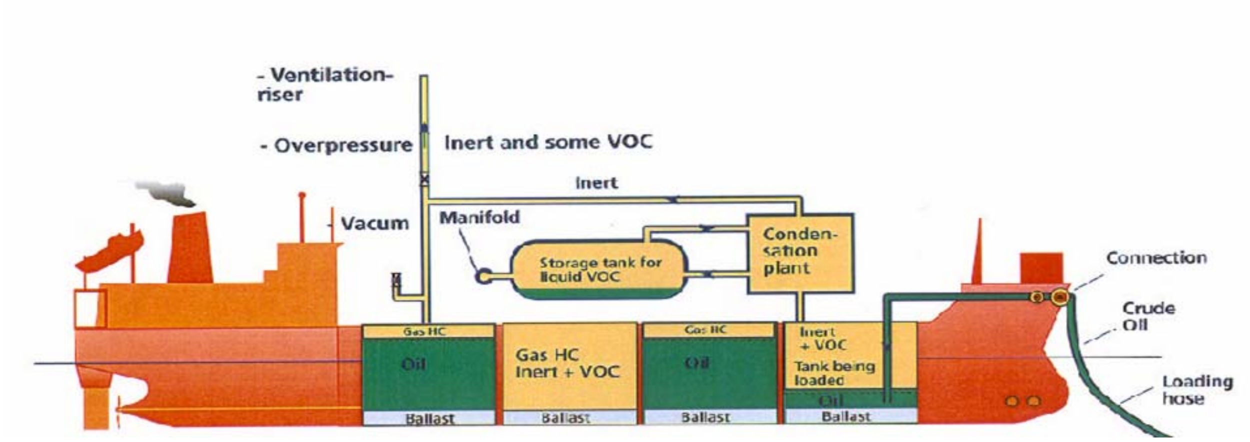
In the late 1990s certain Administrations required offshore installations to reduce their emissions of VOC and this led to the development and installation of vapour recovery systems on board shuttle tankers in the North Sea. Different concepts were developed for the purpose of reducing the emissions of VOC (VOC). The initial efficiency requirement was set to 78% (i.e. 78% less VOC emissions when using vapour recovery systems). The systems can recover VOC in all operational phases.

For ships that have been provided with vapour recovery systems, the VOC emissions will be controlled when the recovery plant is in operation.

The VOC recovery plant efficiency as well as any operational limitations related to, e.g., applicability for different cargo handling modes (loading, transit, COW), maximum allowable loading rates or crude vapour pressures, are to be specified in the VOC management plan.

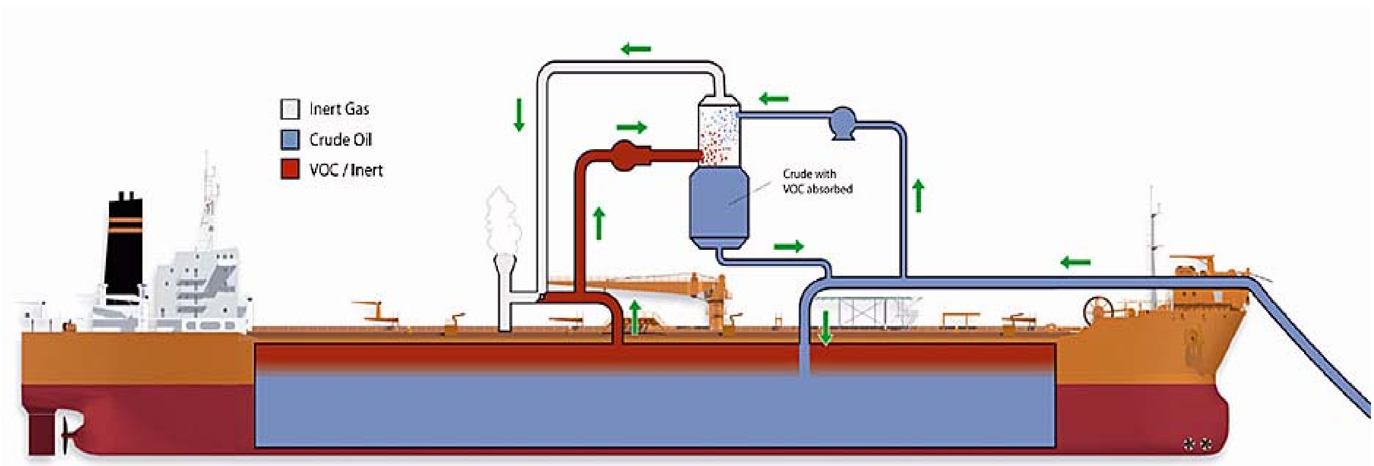
4.1.6.1 **Vapour Recovery Systems – Condensation Systems**

The principle is similar to that of re-liquefaction plants on LPG carriers, i.e. condensation of VOC emitted from cargo tanks. In the process, the VOC passes through a knock out drum before it is pressurized and liquefied in a two stage process. The resulting liquefied gas is stored in a deck tank under pressure and could either be discharged to shore, or be used as fuel (possibly including methane and ethane) for boilers or engines subject to strict safety requirements. It is also conceivable that the stored gas could be used as an alternative to inert gas subject to the Administration's acceptance.



4.1.6.2 **Vapour Recovery Systems – Absorption Systems**

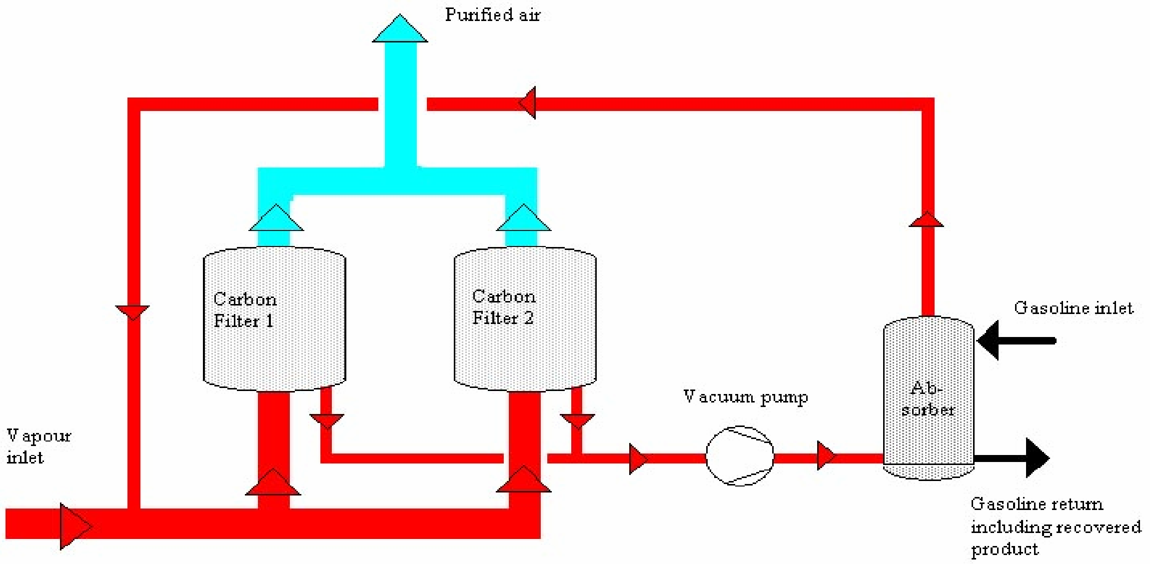
The technology is based on the absorption of VOCs in a counter-current flow of crude oil in an absorber column. The vapour is fed into the bottom of the column, with the side stream of crude oil acting as the absorption medium. The oil containing the absorbed VOC is then routed from the bottom of the column back to the loading line where it is mixed with the main crude oil loading stream. Oil pumps and compressors are used to pressurize the oil and gas. Unabsorbed gases are relieved to the riser to increase the recovery efficiency. Similar concepts have been developed using swirl absorbers instead of an absorption column.



4.1.6.3 **Vapour Recovery Systems – Absorption Carbon Vacuum-Regenerated Adsorption**

In the CVA process, the crude oil vapours are filtered through active carbon, which adsorbs the hydrocarbons. Then the carbon is regenerated in order to restore its adsorbing capacity and adsorb hydrocarbons in the next cycle. The pressure in the carbon bed is lowered by a vacuum pump until it reaches the level where the hydrocarbons are desorbed from the carbon. The extracted, very highly concentrated vapours then pass into the absorber, where the gas is absorbed in a stream of crude oil taken from and returned to the cargo tanks.

As carbon bed adsorption systems are normally sensitive to high concentrations of hydrocarbons in the VOC inlet stream, the VOC feed stream first passes through an inlet absorber where some hydrocarbons are removed by absorption. The recovered VOC stream may be reabsorbed in the originating crude oil in the same inlet absorber.



4.2 Methods and systems for the control of VOC during Transit

4.2.1 Best Practices/Design

.1 Manual pressure relief procedures (tank pressure control);

.2 P/V valve condition and maintenance;

.3 Condition of gaskets for hatches and piping;

.4 Inert gas topping up procedures;

.5 Partially filled tanks;

.6 Loading sequence and rate; and

.7 COW procedures (closed cycle[7]).

4.2.2 VOCON procedure

By reference to Figure 4.2 below, this procedure requires the monitoring and the recording of the pressure drop during a release of gas from the cargo tank vapour system. This can be undertaken with the use of the Inert Gas pressure gauge in the cargo control room or, as available, located on the Inert Gas pipeline on deck. Figure 4.2 shows a pressure drop profile using the mast riser and the inflection in the pressure drop where the mast riser valve should be shut.

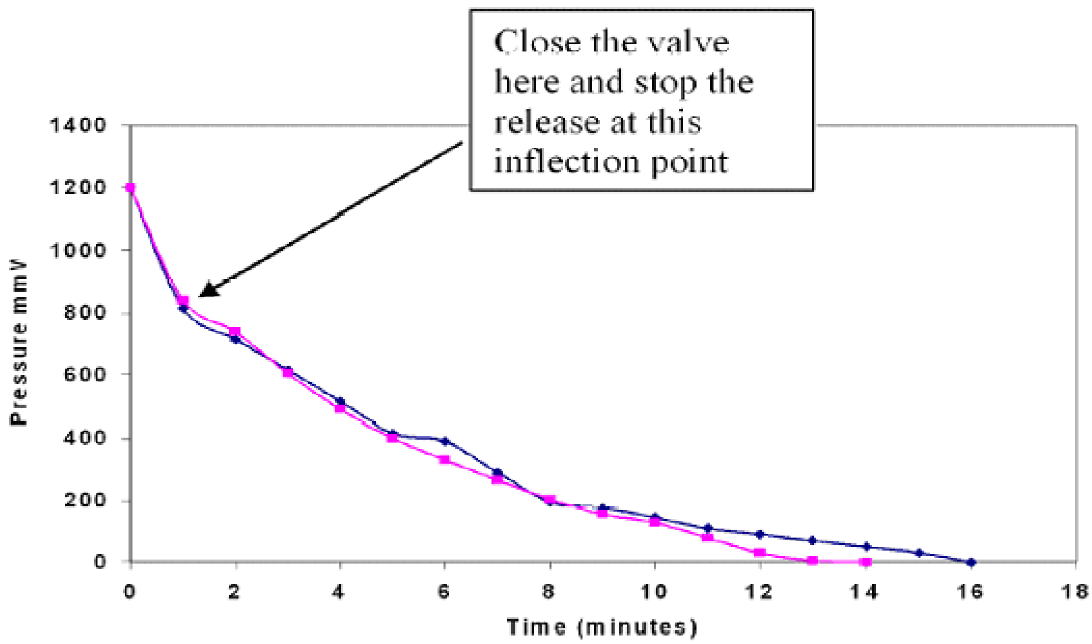


Figure 4.2 – A mast riser release

[7] "Closed Cycle" crude oil washing means that the tanker's slop tank is used as the reservoir for the crude oil wash stock and this wash stock is stripped or cycled back to the slop tank for reuse. Thus, using a defined volume of crude oil for washing of the specified cargo tanks will limit the amount of VOC associated with the wash stock volume as distinct from using fresh crude oil throughout the washing programme.

The VOCON operational procedure

(1) Before opening the mast riser, note the pressure in the Inert Gas pipeline system.

(2) Open the pressure release valve and record/monitor the pressure within the Inert Gas pipeline at regular short intervals (every 30 seconds for a mast riser release).

(3) Plot the pressure drop profile. This can be achieved either manually or by use of the Inert Gas Oxygen and Pressure Recorder in the Cargo Control Room but an increase in the Recorder paper feed rate will be required to achieve definition of the plot.

(4) When the rate of pressure drop becomes constant (after the initial rapid pressure drop) then the gas release should be stopped and the valve closed.

(5) Monitor the Tank Gas Pressure after completion of the controlled release in order to check the final pressure obtained within the Vapour/Inert Gas system.

Advice Notes

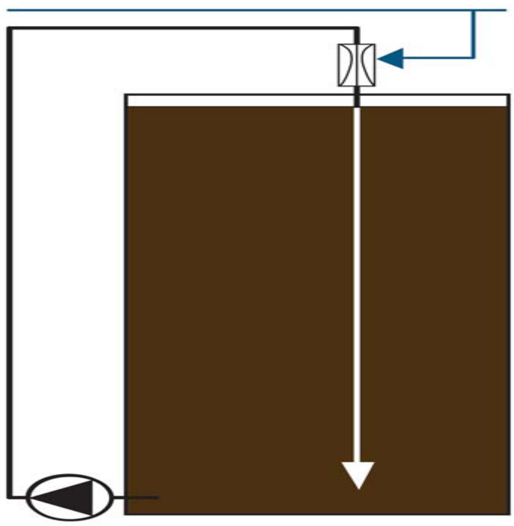
(A) A review of Figure 4.2 shows a clear change in the rate of pressure drop during the release period. If the gas release continues after this point then the pressure in the Inert Gas system will be quickly restored to the pressure associated with the point where the rate of pressure drop changes.

(B) If there is a straight line drop of pressure observed and no inflection observed by 800 mmWG, then close the release valve anyway.

(C) By reference to the ISGOTT Publication, all safety measures should be taken to minimize the hazards associated with vented gases from the vessel's cargo tank system.

4.2.3 **Recovery of excess VOC and tank absorption (Venturi system)**

The Venturi system involves a process where evolved VOC is reabsorbed back into the cargo. The system typically consists of a pressure controlled pump, feeding oil to a unit with Venturi(s). The Venturi draws VOC, H_2S and inert gases (IG) from the common cargo tank venting/inert gas main line. The Venturi unit is designed to generate a bubble size optimal for their collapse in the crude oil cargo and rapid absorption. Released near the tank bottom, the soluble compounds are kept dissolved by the pressure head there. Inert gas will eventually surface.



Oil is pumped from a cargo tank through the Venturi unit. Gas is sucked in from the main inert gas line and injected at the bottom of the tank.

For ships that have been provided with a Venturi type system, the VOC emissions will be controlled when the system is in operation.

The VOC control system efficiency as well as any operational limitations related to, e.g., applicability for different cargo handling modes (loading, transit, COW), maximum allowable loading rates or crude vapour pressures, are to be specified in the VOC management plan.

4.3 Methods and systems for the control of VOC during Discharging/Ballasting

Emissions of VOC during ballasting had relevance when tankers took ballast into cargo tanks for stability and longitudinal strength reasons and thus displaced VOC from cargo tanks being ballasted. After the implementation of requirements to segregated ballast tanks and, of course, double hull, VOC releases during discharge and ballasting are no longer an issue.

During discharging of cargo tanks, it is important that pressure monitoring is exercised in order to avoid excessive supply of inert gas to cargo tanks.

Section 5 – The Monitoring and Control of VOC Releases

5.1 Record keeping is necessary in order to document compliance with the requirements of the management plan and, potentially, the extent of release of gases from the crude oil cargo tanks. The form of record keeping is dependent upon the specific form of method used to minimize the emission of VOC from the crude oil cargo. It will also be dependent upon the operation being performed by the ship necessitating the release of VOC, namely loading during the carriage or as a result of a crude oil washing (COW) operation.

5.2 As a general example of the type and scope of record keeping to be undertaken on board the crude oil tanker, the methodology of the manual VOCON procedure is used. The appropriate record keeping is as follows:

.1 The target or minimum pressure within the tank gas/vapour system for the specific voyage

.1.1 A record of the time and pressure within the tank gas/vapour system before the release takes place.

.1.2 A record of the time and pressure within the gas/vapour system after the release has been completed.

5.3 The foregoing data and information may be compiled by the ship's management company or operators in order to assess or quantify the extent or degree of VOC release. As an outline to such assessment the following can be taken into consideration:

.1 For those ships operating with manual VOC control by the VOCON procedure, the released volume of gas/vapour can be estimated by use of the pressure change (opening to closing pressures) relationship to the total gas/vapour volume in the cargo tank vapour system (Ideal Gas Laws – reference to section 3).

Section 6 – Training Programme

6.1 A training programme is to be developed for the persons intended to assume overall charge of the VOC management on board each ship. The programme is to include the following:

.1 An introduction to the purpose of VOC emission control:

.1.1 Volatile organic compounds (VOCs) may be toxic, and when they evaporate into the air they can react with Nitrogen Oxides (NO_x) in sunlight and split apart oxygen molecules in air and thereby form ground-level ozone, commonly referred to as smog. The layer of brown haze it produces is not just an eyesore, but also is a source of serious illnesses. Ozone is extremely irritating to the airways and the lungs, causing serious damage to the delicate cells lining the airways. It contributes to decreased lung function, increased respiratory symptoms and illnesses.

.1.2 Regulation 15 of MARPOL Annex VI

.2 An introduction to the principles of VOC emission control:

.2.1 VOC generation systems in crude oil (ref. section 3)

.2.2 Crude oil tanker pressure control/release systems (ref. section 2)

.3 General VOC emission control options:

.3.1 Methods and systems for the control of VOC emissions (ref. section 4)

.4 Ship specific VOC emission control options:

.4.1 Ship specific methods and systems for the control of VOC emissions (ref. section 4)

.5 Monitoring and recording of VOC release:

.5.1 Methods for monitoring and recording of VOC emissions (ref. section 5)

.6 Hazards and Safety related to VOC emission control:

.6.1 The hull and its pressure limitations (ref. section 1)

.6.2 Personnel safety hazards related to exposure to crude oil vapour.

Section 7 – Designated Person

7.1 A person should be designated to assume overall charge of the VOC management on board the ship.

The designated person should preferably have:

.1 At least one year's experience on crude oil tankers where his or her duties have included all cargo handling operations relevant to VOC management. In the absence of experience with VOC management, he or she should have completed a training programme in VOC management as specified in the VOC management plan;

.2 participated at least twice in cargo loading operations, Crude Oil Washing Operations and transit where VOC management procedures have been applied, one of which should be on the particular ship or a similar ship in all relevant aspects, for which he or she is to undertake the responsibility of VOC management; and

.3 full knowledge of the contents of the VOC management plan.

Section 8 – List of drawings

8.1 The following drawings are recommended included as appendices to the management plan:

.1 General Arrangement drawing;

.2 Tank plan;

.3 Schematic drawing(s) of the Cargo tank venting system;

.4 Schematic drawing of the inert gas system;

.5 Schematic drawing of the vapour emission control systems (if applicable);

.6 Schematic drawing(s) Vapour Recovery System or other VOC control systems; and

.7 Details of pressure vacuum relief devices including settings and capacities.

References:

.1 Vapour Emission Control System manual (if applicable);

.2 Vapour Recovery System manual (if applicable);

.3 Other VOC control system manual (if applicable);

.4 Inert Gas manual; and

.5 COW manual.

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ATTACHMENT 3 - DETAILED EMISSION CALCULATIONS

Texas Gulf Terminals Inc.
Normal Operations Emission Calculations
Marine Loading (DWP Emissions Source for PSD Applicability)
Criteria Pollutants

Hourly and Annual VOC Emissions Estimates for Loading of Crude Oil and Condensate

Hourly Loading Emissions

Liquid Loaded [1]	Saturation Factor [2]	Maximum Temp [3]		Vapor MW	Maximum True Vapor Pressure (TVP) [4]	Arrival Emission Factor [5]	Generated Emission Factor [6]	Uncontrolled Loading Loss [7]	TOC to VOC Factor	Hourly Loading Rate [8]	Uncontrolled VOC Hourly Emissions [9]
		(˚F)	(˚R)	(lb/lb mol)	(psia)	(lb/1,000 gal)	(lb/1,000 gal)	(lb/1,000 gal)		(bbl/hr)	(lb/hr)
Crude Oil	0.2	73.50	533.17	50	11.00	--	--	2.57	1.00	60,000	6,478.07
Condensate	0.2	73.50	533.17	60	11.00	--	--	3.08	1.00	60,000	7,773.68

[1] For hourly emission estimates, the worst-case marine loading commodity between Crude oil and Condensate will be utilized.

[2] Saturation factor for marine loading obtained from U.S. EPA 42, Section 5.2 (1/95), Table 5.2-1.

[3] Maximum of monthly average liquid surface temperature was used .

[4] Maximum true vapor pressure for Crude oil and Condensate obtained from information provided by Texas Gulf Terminals

[5] Arrival emission factor for crude/condensate loading obtained from U.S. EPA 42, Section 5.2 (1/95), Table 5.2-3.

[6] Generated emission factor is calculated using equation 3 from U.S. EPA 42, Section 5.2 (1/95).

[7] Uncontrolled Loading Loss (lb/1,000 gal) = 12.46 x Saturation Factor x Maximum TVP of Liquid Loaded (psia) x Vapor MW (lb/lbmol) / Maximum Temperature of Bulk Liquid Loaded (^{o}R)

$$\text{Crude Oil Uncontrolled Loading Loss (lb/1,000 gal)} = \frac{12.46}{} \Big| \frac{0.2}{} \Big| \frac{11.00 \text{ psia}}{} \Big| \frac{50 \text{ lb}}{\text{lbmole}} \Big| \frac{1}{533.17 \text{ R}} = 2.57 \text{ lb/1,000 gal}$$

[8] Hourly Loading Rate obtained from information provided by TGTI Revised Design Parameters email from Ms. Denise Rogers (TGTI) to Mr. Brian Burdorf (Trinity Consultants) on February 25, 2018.

[9] Uncontrolled VOC Hourly Emissions (lb/hr) = Uncontrolled Loading Loss (lb/1,000 gal) x Hourly Loading Rate (bbl/hr) x 42 gal/bbl x TOC to VOC Factor x (1/1,000)

$$\text{Crude Oil Uncontrolled Loading Emissions (lb/hr)} = \frac{2.57 \text{ lb}}{1{,}000 \text{ gal}} \Big| \frac{60{,}000 \text{ bbl}}{\text{hr}} \Big| \frac{42 \text{ gal}}{\text{bbl}} \Big| \frac{1.00}{} \Big| \frac{1}{1{,}000} = 6{,}478 \text{ lb/hr}$$

Texas Gulf Terminals Inc.
Normal Operations Emission Calculations
Marine Loading (DWP Emissions Source for PSD Applicability)
Criteria Pollutants

Annual Loading Emissions

Liquid Loaded [1]	Saturation Factor [2]	Annual Average Temp [3]		Vapor MW	Average True Vapor Pressure (TVP) [4]	Arrival Emission Factor [5]	Generated Emission Factor [6]	Uncontrolled Loading Loss [7]	TOC to VOC Factor	Annual Loading Rate [8]	Uncontrolled VOC Annual Emissions [9]
		(˚F)	(˚R)	(lb/lb mol)	(psia)	(lb/1,000 gal)	(lb/1,000 gal)	(lb/1,000 gal)		(bbl/yr)	(tpy)
Crude Oil	0.2	73.50	533.17	50	11.00	--	--	2.57	1.00	192,000,000	10,364.91
Condensate	0.2	73.50	533.17	62	9.25	--	--	2.68	1.00	192,000,000	10,807.77

[1] For annual emission estimates, the worst-case marine loading commodity between Crude oil and Condensate will be utilized.

[2] Saturation factor for marine loading obtained from U.S. EPA 42, Section 5.2 (1/95), Table 5.2-1.

[3] Average of monthly average liquid surface temperature was used .

[4] Average true vapor pressure for Crude oil and Condensate obtained from information provided by Texas Gulf Terminals

[5] Arrival emission factor for crude/condensate loading obtained from U.S. EPA 42, Section 5.2 (1/95), Table 5.2-3.

[6] Generated emission factor is calculated using equation 3 from U.S. EPA 42, Section 5.2 (1/95).

[7] Uncontrolled Loading Loss (lb/1,000 gal) = 12.46 x Saturation Factor x Average TVP of Liquid Loaded (psia) x Vapor MW (lb/lbmol) / Average Temperature of Bulk Liquid Loaded (^oR)

$$\text{Crude Oil Uncontrolled Loading Loss (lb/1,000 gal)} = \frac{12.46}{} \cdot \frac{0.2}{} \cdot \frac{11.00 \text{ psia}}{} \cdot \frac{50 \text{ lb}}{\text{lbmole}} \cdot \frac{1}{533.17 \text{ R}} = 2.57 \text{ lb/1,000 gal}$$

[8] Annual Loading Rate obtained from information provided by TGTI Revised Design Parameters email from Ms. Denise Rogers (TGTI) to Mr. Brian Burdorf (Trinity Consultants) on February 25, 2018 and June 22, 2018.

[9] Uncontrolled VOC Loading Emissions (tpy) = Uncontrolled Loading Loss (lb/1,000 gal) x Annual Loading Rate (bbl/yr) x 42 gal/bbl x TOC to VOC Factor x (1/1,000) x (1 ton/2,000 lb)

$$\text{Crude Oil Uncontrolled Loading Emissions (tpy)} = \frac{2.57 \text{ lb}}{1{,}000 \text{ gal}} \cdot \frac{192{,}000{,}000 \text{ bbl}}{\text{yr}} \cdot \frac{42 \text{ gal}}{\text{bbl}} \cdot \frac{1.00}{} \cdot \frac{1}{1{,}000} \cdot \frac{1 \text{ ton}}{2{,}000 \text{ lb}} = 10{,}365 \text{ tpy}$$

Texas Gulf Terminals Inc.
Normal Operations Emission Calculations
Marine Loading (DWP Emissions Source for PSD Applicability)
Criteria Pollutants

Hourly and Annual H_2S Emissions Estimates for Loading of Crude Oil and Condensate

Parameter	Value	Unit
H_2S MW	34.1	lb/lbmol
H_2S Max Vapor Fraction in Crude oil [1]	2.40E-05	
H_2S Max Vapor Fraction in Condensate [1]	2.40E-05	
Maximum Mass Ratio of H_2S in Crude Oil [2]	2.19E-05	lb H_2S/lb VOC
Maximum Mass Ratio of H_2S in Condensate [2]	1.76E-05	lb H_2S/lb VOC

[1] Maximum H_2S vapor fraction is assumed to be 24 ppmv for sweet crude.

[2] H_2S Mass Ratio in Crude Oil/Condensate (lb H_2S/lb VOC) = H_2S Vapor Fraction in Crude Oil/Condensate x H_2S MW (lb/lbmole)/Crude Oil/Condensate Vapor MW (lb/lbmole) x 14.7 psia/Vapor Pressure of Crude Oil/Condensate (psia)

$$\text{Max } H_2S \text{ Mass Ratio in Crude Oil (lb } H_2S\text{/lb VOC)} = 2.40\text{E-05} \times \frac{34.1 \text{ lb}}{\text{lbmole}} \times \frac{\text{lbmole}}{50 \text{ lb}} \times \frac{14.7 \text{ psia}}{11 \text{ psia}} = 2.19\text{E-05 lb H2S/lb VOC}$$

Liquid Loaded [1]	Maximum TVP [2] (psia)	Uncontrolled VOC Hourly Emissions (lb/hr)	Uncontrolled VOC Annual Emissions (tpy)	H_2S Hourly Emissions [3] (lb/hr)	H_2S Annual Emissions [4] (tpy)
Crude Oil	11.00	6,478	10,365	0.14	0.23
Condensate	11.00	7,774	10,808	0.17	0.24

[1] For hourly and annual emission estimates, the worst-case marine loading commodity between Crude oil and Condensate will be utilized.

[2] Maximum true vapor pressure for Crude oil and Condensate obtained from information provided by Texas Gulf Terminals

[3] H_2S Hourly Emissions (lb/hr) = Max H_2S Mass Ratio in Crude/Condensate (lb H_2S/lb VOC) x Uncontrolled VOC Hourly Emissions (lb/hr)

$$H_2S \text{ Hourly Emissions from Crude Oil (lb/hr)} = \frac{2.19\text{E-05 lb H2S}}{\text{lb VOC}} \times \frac{7{,}774 \text{ lb}}{\text{hr}} = 0.14 \text{ lb/hr}$$

[4] H_2S Annual Emissions (tpy) = Max H_2S Mass Ratio in Crude/Condensate (lb H_2S/lb VOC) x Uncontrolled VOC Annual Emissions (tpy)

$$H_2S \text{ Annual Emissions from Crude Oil (tpy)} = \frac{2.19\text{E-05 lb H2S}}{\text{lb VOC}} \times 10{,}808 \text{ tpy} = 0.23 \text{ tpy}$$

Texas Gulf Terminals Inc.
Normal Operations Emission Calculations
Marine Loading (DWP Emissions Source for PSD Applicability)
Hazardous Air Pollutants

Parameter	Value	Unit
Max. benzene vapor weight % in Crude Oil [1]	0.95%	
Max. benzene vapor weight % in Condensate [1]	0.43%	
Max toluene Vapor weight % in Crude Oil [1]	0.98%	
Max toluene Vapor weight % in Condensate [1]	0.37%	

[1] Benzene and toluene vapor weight fraction is based on Tanks 4.09D run.

Pollutant	Liquid Loaded [1]	Uncontrolled VOC Hourly Emissions (lb/hr)	Uncontrolled VOC Annual Emissions (tpy)	Maximum Emissions [2] (lb/hr)	Annual Emissions [3] (tpy)
Benzene	Crude Oil	6,478	10,365	61.54	98.47
	Condensate	7,774	10,808	33.43	46.47
Toluene	Crude Oil	6,478	10,365	63.49	101.58
	Condensate	7,774	10,808	28.76	39.99

[1] For hourly and annual emission estimates, the worst-case marine loading commodity between Crude oil and Condensate will be utilized.

[2] Benzene Hourly Emissions (lb/hr) = Max Benzene % in Crude/Condensate Vapors x Uncontrolled VOC Hourly Emissions (lb/hr)

[3] Emissions are based on the total VOC emissions for Loading of Crude Oil and Condensate calculated in the previous table.

Benzene Hourly Emissions from Crude Oil (lb/hr) = 0.95% | 6,478 lb / hr = 61.54 lb/hr

Toluene Hourly Emissions (lb/hr) = Max Toluene % in Crude/Condensate Vapors x Uncontrolled VOC Hourly Emissions (lb/hr)

Toluene Hourly Emissions from Crude Oil (lb/hr) = 0.98% | 6,478 lb / hr = 63.49 lb/hr

[3] Benzene Annual Emissions (tpy) = Max Benzene % in Crude/Condensate Vapors x Uncontrolled VOC Annual Emissions (tpy)

Benzene Annual Emissions from Crude Oil (tpy) = 0.95% | 10,365 tons / yr = 98.47 tpy

Toluene Annual Emissions (tpy) = Max Toluene % in Crude/Condensate Vapors x Uncontrolled VOC Annual Emissions (tpy)

Toluene Annual Emissions from Crude Oil (tpy) = 0.98% | 10,365 tons / yr = 101.58 tpy